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THE JOURNAL
OF
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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O.K.

The professional papers contained in The Journal are published prior to the meetings at which they are to be presented, in order to afford members an opportunity to prepare any discussion which they may wish to present.

The Society as a body is not responsible for the statements of facts or opinions advanced in papers or discussions. C55.

THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL. 33 JUNE 1911 NUMBER 6

SPRING MEETING, PITTSBURG, MAY 30-JUNE 2

The Spring Meeting of The American Society of Mechanical Engineers, to be held at Pittsburg, Pa., May 30 to June 2, 1911, will have a program of exceptional professional interest, supplemented by technical excursions and social gatherings, which should make it one of the most valuable as well as enjoyable conventions ever held by the Society. The professional sessions have as usual been arranged by the Committee on Meetings, while all other events are in charge of the Local Committee, E. M. Herr, Chairman.

The headquarters of the convention will be the Hotel Schenley and the professional sessions will be held at the Carnegie Institute, in close proximity to the hotel.

PROGRAM

Tuesday Morning and Afternoon, May 30

Registration at headquarters at the Hotel Schenley.

Inspection of the Foundry and Machine Exhibition Company's Exhibit at Exposition Building.

Tuesday Evening, 8.30

Informal reception for the members and ladies of the Society in the parlors of the Hotel Schenley.

PROFESSIONAL SESSION

Business meeting. Reports of Tellers of Election and Committees. New Business.

Wednesday, May 31, 10 a.m.

MECHANICAL ENGINEERING OF CEMENT MANUFACTURE

SOME PROBLEMS OF THE CEMENT INDUSTRY, Walter S. Landis.
THE EDISON ROLL CRUSHERS, W. H. Mason.
POWER AND HEAT DISTRIBUTION IN CEMENT MILLS, L. L. Griffiths.

Wednesday Afternoon

Excursion by special train to the plant of the Universal Portland Cement Company, Universal, upon invitation of Mr. E. M. Hagar, President.

The train will stop at East Pittsburg, both going and returning, to permit those who desire to inspect the works of the Westinghouse Electric & Manufacturing Company and the Westinghouse Machine Company.

Inspection of the Foundry and Machine Exhibition Company's Exhibit at Exposition Building.

Wednesday Evening, 8.30

SESSION ON MACHINE SHOP PRACTICE

THE ASSEMBLY OF SMALL INTERCHANGEABLE PARTS, John Calder.
THE PROCESS OF ASSEMBLING A SMALL AND INTRICATE MACHINE, Halcolm Ellis.
QUANTITY MANUFACTURE OF SMALL DEVICES, F. P. Cox.
MILLING CUTTERS AND THEIR EFFICIENCY, A. L. De Leeuw.

GAS POWER SESSION

Business meeting, followed by discussions constituting a symposium on Large Gas Power Plants. A. E. Maccoun of the Carnegie Steel Company will open the discussion and will be followed by representatives of the leading firms building large gas engines and producers.

A pamphlet has been prepared by W. E. Snyder of the American Steel and Wire Company, for distribution at the meeting, illustrating and describing the principal gas power plants in the Pittsburg district.

THE WORK OF THE U. S. BUREAU OF MINES, S. B. Flagg and C. D. Smith.

Thursday, June 1, 10 a.m.

MISCELLANEOUS SESSION

STRESSES IN TUBES, Reid T. Stewart.
THE PURCHASE OF COAL, D. T. Randall.
ENERGY AND PRESSURE DROP IN COMPOUND STEAM TURBINES, F. E. Cardullo.
THE PRESSURE-TEMPERATURE RELATIONS OF SATURATED STEAM,* L. S. Marks.
PRESSURE RECORDING INDICATOR FOR PUNCHING MACHINERY, G. C. Anthony.

Thursday Afternoon

Excursion up the Monongahela River for members and ladies, including inspection trip to the National Tube Company's works at McKeesport.

Thursday Evening

Reception and dance at the Hotel Schenley for members and ladies.

Friday, June 2, 10 a.m.

SESSION ON STEEL WORKS PRACTICE

COMMERCIAL APPLICATION OF THE TURBINE TURBO-COMPRESSOR, R. H. Rice.
RECIPROCATING BLAST-FURNACE BLOWING ENGINES, W. Trinks.
POWER FORGING WITH SPECIAL REFERENCE TO STEAM-HYDRAULIC FORGING PRESSES, Berthold Gerdau and George Mesta.

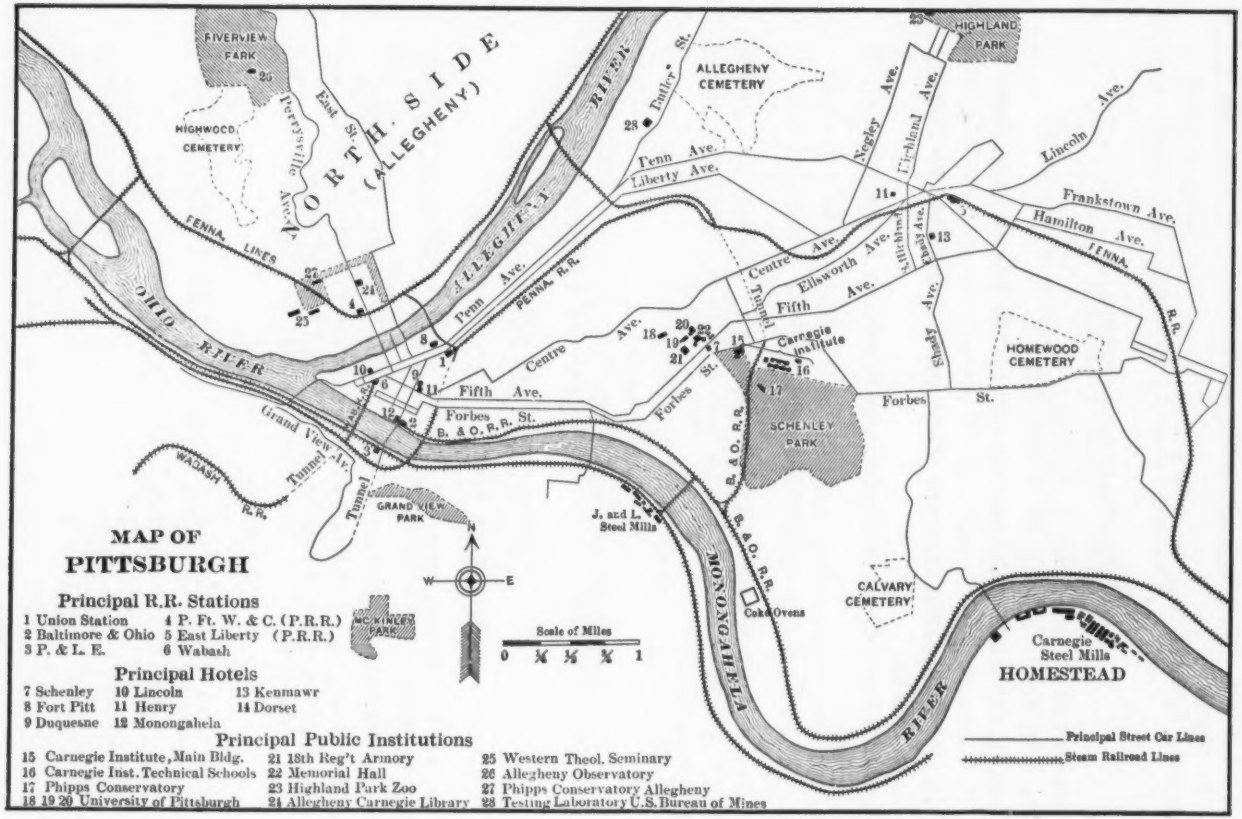
Friday Afternoon

Inspection trip to Mesta Machine Company's works at Homestead.

Friday Evening

Smoker and entertainment given in honor of The American Society of Mechanical Engineers by the Engineers' Society of Western Pennsylvania in their rooms in the Oliver Building.

*To be read by title only.


FIVERVIEW PARK
HIGHWOOD CEMETERY
NORTH SIDE (ALLEGHENY)
ALLEGHENY RIVER
OHIO RIVER
ALLEGHENY CEMETERY
HIGHLAND PARK
Penna. Lines
Penn Ave.
Liberty Ave.
Centre Ave.
Fifth Ave.
Forbes St.
Grand View Ave.
Tunnel
Carnegie Institute
SCHENLEY PARK
HOMEWOOD CEMETERY
GRAND VIEW PARK
McKINLEY PARK
J. and L. Steel Mills
B. & O. R.R.
MONONGAHELA RIVER
CALVARY CEMETERY
Coke Ovens
Carnegie Steel Mills
HOMESTEAD
MAP OF PITTSBURGH
Principal R.R. Stations
1 Union Station
2 Baltimore & Ohio
3 P. & L. E.
4 P. Ft. W. & C. (P.R.R.)
5 East Liberty (P.R.R.)
6 Wabash
Principal Hotels
7 Schenley
8 Fort Pitt
9 Duquesne
10 Lincoln
11 Henry
12 Monongahela
13 Kenmawr
14 Dorset
Principal Public Institutions
15 Carnegie Institute, Main Bldg.
16 Carnegie Inst. Technical Schools
17 Phipps Conservatory
18 19 20 University of Pittsburgh
21 18th Reg't Armory
22 Memorial Hall
23 Highland Park Zoo
24 Allegheny Carnegie Library
25 Western Theol. Seminary
26 Allegheny Observatory
27 Phipps Conservatory Allegheny
28 Testing Laboratory U.S. Bureau of Mines
Scale of Miles
0 ¼ ½ ¾ 1
Principal Street Car Lines
Steam Railroad Lines

LADIES' PROGRAM

The Ladies' Committee, Mrs. Chester B. Albree, Chairman, have prepared a program for the visiting ladies, which includes the following events, in addition to those scheduled on the general program to which ladies are invited. It is probable that there will be additional features which cannot be announced at this date.

Wednesday Morning, May 31

Inspection of the Margaret Morrison Carnegie School for Women, of the Carnegie Institute.
Luncheon at the Pittsburg Golf Club.

Wednesday Afternoon

Tea at the Twentieth Century Club.

Wednesday Evening

Visit to Annual Exhibit of the Carnegie Art Galleries.

Thursday Morning, June 1

Inspection of Carnegie Institute and the new Athletic Club.

Friday Morning, June 2

Inspection of the Heinz Pickle Works.
Automobile drive through East End Parks.

Friday Afternoon

Automobile drive to Sewickley.
Tea at the Allegheny Country Club.

RAILROAD TRANSPORTATION NOTICE

Arrangements for hotel, transportation and Pullman car accommodations should be made personally.

Special concessions have been secured for members and guests attending the Spring Meeting in Pittsburg, May 30 to June 2, 1911.

The special rate of a fare and three-fifths for the round trip, on the certificate plan, is granted when the regular fare is 75 cents and upwards, from territory specified below.

a Buy your ticket at full fare for the going journey, between May 26 and June 1 inclusive. At the same time request a certificate, *not a receipt*. This ticket and certificate should be secured at least half an hour before the departure of the train.

b Certificates are not kept at all stations. Ask your station agent whether he has certificates and through tickets. If not, he will tell you the nearest station where they can be obtained. Buy a local ticket to that point, and there get your certificate and through ticket.

c On arrival at the meeting, present your certificate to S. Edgar Whitaker, office manager, at Headquarters. A fee of 25 cents will be collected for each certificate validated. No certificate can be validated after June 2.

d An agent of the Trunk Line Association will validate certificates, May 31, June 1, 2. No refund of fare will be made on account of failure to have certificate validated.

e One-hundred certificates and round trip tickets must be presented for validation before the plan is operative. This makes it important to show the return portion of your round trip ticket at Headquarters.

f If certificate is validated, a return ticket to destination can be purchased, up to June 6, on the same route over which the purchaser came, at three-fifths the rate.

The special rate is granted only for the following:

The Trunk Line Association:

All of New York east of a line running from Buffalo to Salamanca, all of Pennsylvania east of the Ohio River, all of New Jersey, Delaware and Maryland;

also that portion of West Virginia and Virginia north of a line running through Huntington, Charleston, White Sulphur Springs, Charlottesville, and Washington, D. C.

The New England Passenger Association except via Eastern Steamship Co.

Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut.

HOW TO REACH PITTSBURG

FROM NEW YORK

Via Pennsylvania Railroad:

	No. 25	No. 43	No. 9	No. 19	No. 37
Lv. New York..	8.04 a.m.	10.04 a.m.	6.04 p.m.	8.30 p.m.	10.08 p.m.
Arr. Pittsburg..	5.52 p.m.	6.55 p.m.	5.55 p.m.	6.30 a.m.	8.00 a.m.

No. 25 dining car from Philadelphia; No. 9 dining car: No. 43 observation dining car: No. 37 dining car.

This company will be glad to make Pullman reservations on application, and its representatives will deliver tickets to members if desired. Address applications to 263 Fifth Avenue, New York.

Via Baltimore and Ohio Railroad:

Lv. New York.....	7.50 a.m.	3.50 p.m.	6.50 p.m.
Arr. Pittsburg.....	8.50 p.m.	5.55 a.m.	8.05 p.m.

Fare to Pittsburg, $9 for through ticket and $10.50 for ticket allowing stopover at Philadelphia, Baltimore or Washington. Offices, 434 Broadway, New York.

FROM WESTERN POINTS

Via Pennsylvania Railroad:	No. 16	No. 22	No. 24
Lv. Chicago.....	8.15 a.m.	10.30 a.m.	8.00 p.m.
Lv. Fort Wayne.....	12.03 p.m.	2.05 p.m.	11.55 p.m.
Arr. Pittsburg.....	8.10 p.m.	9.55 p.m.	8.15 p.m.

	No. 24	No. 30	No. 44	No. 18	No. 14
Lv. St. Louis..	12.40 p.m.	4.30 p.m.	5.00 p.m.	8.15 p.m.	11.35 p.m.
" Indianapolis	7.20 p.m.	10.20 p.m.	11.25 p.m.	3.35 a.m.	8.10 a.m.
" Cincinnati..	9.00 p.m.	.....	.....	.....	7.30 a.m.
" Columbus...	12.40 a.m.	2.35 a.m.	4.05 a.m.	8.55 a.m.	12.50 a.m.
Arr. Pittsburg..	6.05 a.m.	6 55 a.m.	8.45 a.m.	2.30 p.m.	5.50 p.m.

No. 22, all Pullman cars $2 extra fare: No. 30, all Pullman cars $2.50 extra fare.

HOTEL RATES FOR SPRING MEETING AT PITTSBURG

Minimum Rates

	Without Bath			With Bath		
	Single Room	Single Room Two Persons	Double Room Two Persons	Single Room	Single Room Two Persons	Double Room Two Persons
Hotel Schenley	$2.00	$3.00	$—	$3.00	$4.00	$5.00
Fort Pitt Hotel	1.50	—	2.50	2.50	—	3.50
	2.00	—	3.00	5.00		7.00
Hotel Henry	1.50	2.50	3.00	2.50	3.50	4.00
	2.00	up	up	up	up	up
Monongahela House	1.50	—	2.00	2.50	—	4.00
	2.00		3.00	3.00		5.00
Hotel Anderson	1.00	1.50	3.00	2.50	—	4.00
		2.00	4.00	3.50		
Duquesne Hotel	1.50	—	2.50	2.50	—	3.50
Hotel Lincoln	1.50	—	2.00	2.00	—	3.00
	2.50	—	4.00	3.00		5.00
Seventh Avenue Hotel	1.50	2.50	3.00	2.50	4.00	5.00
Colonial Annex Hotel	1.50	2.00	2.50	2.00	3.00	3.50
						5.00
The Dorset	1.00	—	2.00	2.00	—	3.00
Hotel Lorraine*	2.50	—	4.00	3.00	—	5.00
				3.50		6.00

*American plan.

LOCAL COMMITTEE

E. M. Herr, *Chairman*
Elmer K. Hiles, 2511 Oliver Bldg., *Secretary*
George Mesta, Chairman Committee on Finance
John M. Tate, Chairman Committee on Entertainment
Chester B. Albree, Chairman Committee on Hotels
Morris Knowles, Chairman Committee on Printing
D. F. Crawford, Chairman Committee on Transportation
Mrs. Chester B. Albree, Chairman Ladies' Committee

MONTHLY MEETINGS

PHILADELPHIA MEETING, JUNE 3

On account of the interest manifested on the subject of Fuel Testing, considered at the meeting in Philadelphia on April 22, when a paper by J. C. Parker of that city on the Work of the United States Fuel Testing Station was presented, the meeting on June 3 in that city will be given up to further discussion of the same topic. As this will follow immediately after the Spring Meeting in Pittsburg, members passing through Philadelphia will have an opportunity to be present and to take part in the discussion. The Engineers Club of Philadelphia will coöperate in the meeting.

ST. LOUIS MEETING, JUNE 7

The meeting of the Society in St. Louis on June 7 will take the form of a banquet, held at the Mercantile Club in that city under the auspices of the Engineers Club of St. Louis, in which the members of the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Society of Engineering Contractors, as well as of the Society will participate. Col. E. D. Meier, President, will be the chief speaker of the evening.

SAN FRANCISCO MEETING, JUNE 28

At a meeting of the Society in San Francisco on June 28, the Use of Fuel Oil considered at the meeting of March 10, will receive further discussion. A paper upon the Control of Surges in Water Conduits will be presented by the author, W. F. Durand, professor of mechanical engineering of Stamford University.

PROVIDENCE MEETING, MAY 3

The first meeting of the Society in Providence was held in the West Side Club on May 3, 1911, the Providence Association of Mechanical Engineers coöperating, with an attendance of nearly 200. The Society was officially represented by Col. E. D. Meier, President, F. R. Hutton, Honorary Secretary, and Calvin W. Rice, Secretary. At

the conclusion of an informal reception in the parlors of the club the guests sat down to a banquet in the large dining hall. Edwin C. Bliss, Mem. Am. Soc. M. E. and President of the Providence Association of Mechanical Engineers, gave an address of welcome, outlining briefly the history of the Providence association and dwelling somewhat upon the work done by it in inaugurating in Providence the half-time course of industrial education for machinists. The toastmaster of the evening, Williams Howard Paine, was then introduced and paid a high tribute to the many natives of Providence who had become prominent in the mechanical field, including Robert Henry Thurston, Past President, Am.Soc.M.E., George H. Corliss, Noble T. Greene, Lucian Sharpe, and a number of others.

In response to the toast, The American Society, Calvin W. Rice said that this inauguration of affiliation meetings meant much to the engineering profession, and described in some detail how the Society carries on its work. He was followed by Col. E. D. Meier who, in replying to the toast, The Affiliation of the Two Societies, told of the advantages such an affiliation would bring and gave a brief outline of the organization and growth of the various engineering societies of the country, showing that while the early tendency was toward specialization and segregation, the present movement was directed to affiliation.

The final speaker of the evening, F. R. Hutton, gave a short address upon Safety Appliances, dividing his subject into three topics, what is an accident, who is to prevent accidents, and is the prevention of accidents not practicable. He claimed that accidents were of two classes, preventable and non-preventable, and by the aid of nearly 100 lantern slides described the means that are being taken in this country and abroad to protect the employees from accidents of all kinds.

NEW YORK MEETING, MAY 9

At the monthly meeting of the Society in New York, on May 9, the subject of Patent Law was considered, with papers on the More Fundamental Principles of Patent Law, by Edwin J. Prindle, Letters Patent for Inventions, by D. Howard Haywood, and the Patent Expert, by E. W. Marshall, dealing with the question of patent rights and the protection they afford, and with the method of securing the benefits of the patent law as well as of avoiding its abuses. The papers were discussed by A. Parker Smith, lawyer and patent expert, New York, Frank M. Ashley, patent attorney and consulting engineer, New York, and W. S. Rogers, president of the Bantam

Anti-Friction Company of Bantam, Conn. A written discussion was presented by Alonzo B. See, of the A. B. See Electric Elevator Company, New York.

BOSTON MEETING, MAY 17

A meeting of the Society was held in Boston on May 17 in coöperation with the Boston Society of Civil Engineers and the Boston Section of the American Institute of Electrical Engineers, the program of the evening being in charge of the latter organization. A paper on the Electric Motor in the World's Work was presented by the author, Fred. M. Kimball, Assoc.A.I.E.E., Manager of the small motor department of the General Electric Company, West Lynn, Mass., in which he briefly described the development of the electric motor from the discovery of the fundamental principles early in the nineteenth century up to the present time. He exhibited a large number of lantern slides showing the very diversified application of the motor to various industries. On account of the character and length of the paper there was no discussion. About 150 attended the meeting, which was the final one of a very successful series held in Boston during the season 1910–1911.

BILL FOR LICENSING ENGINEERS

The committee of engineers appointed to deal with the subject of the bill for licensing engineers, Col. E. D. Meier, President Am.Soc. M.E., Chairman, Alfred P. Boller, R. S. Buck, C. W. Baker, Mem. Am.Soc.M.E., George B. Francis, E. G. Spilsbury, Mem.Am.Soc.M. E., and Frank J. Sprague, has ascertained that no further action is likely to be taken upon this bill at this session of the legislature.

ADDRESS BY THE PRESIDENT AT N. A. C. M. MEETING

At the annual meeting of the National Association of Cotton Manufacturers held in Boston, Mass., April 12–13, 1911, Col. E. D. Meier represented the Society and spoke briefly of the relation of the mechanical engineer to the cotton industry. At the close of the meeting the following resolution was adopted:

Resolved, that the thanks of this Association be expressed to Col. E. D. Meier, President of The American Society of Mechanical Engineers, for his contribution which added so much to the pleasure of the meeting.

STUDENT BRANCHES

COLUMBIA UNIVERSITY

At a meeting of the Columbia University Student Branch, April 21, L. De G. Moss gave an interesting talk on the value of studying engineering in its various branches. Election of officers for the school year, 1911–1912, resulted as follows: N. E. Hendrickson, president; E. Mosher, vice-president; Mr. Ruprecht, secretary; Mr. Stone, treasurer.

OHIO STATE UNIVERSITY

A special meeting of the Ohio State University Student Branch was held April 10 and a paper on Steam Turbines was presented by Mr. McClelland. The regular monthly meeting at which a paper on Smoke Prevention, by Mr. Griffin was read, was held April 20. The subject aroused general interest and a liberal discussion followed the reading.

PENNSYLVANIA STATE COLLEGE

The Student Branch of the Pennsylvania State College held a meeting, April 25, at which a paper on The Manufacture of Locomotive Tires by C. E. Dahl was presented.

PURDUE UNIVERSITY

Theodore Weinshank, Mem.Am.Soc.M.E., addressed the meeting of the Purdue University Student Branch on April 19, his subject being Types of Feed Water Heaters and Purifiers. The discussion was illustrated by lantern slides and many practical and instructive points were brought out by the speaker. On May 3, the meeting was addressed by H. S. Dickerson on the subject of the Indicator Optique, or manograph, recently invented by O. Schulze.

STATE UNIVERSITY OF KENTUCKY

At a meeting of the State University of Kentucky Student Branch, April 25, J. B. Stanwood, Mem.Am.Soc.M.E., lectured on Special Features of Slide Valve Engines, devoting most of his attention to some experimental work in connection with the leakage of a balanced slide valve which has given excellent results. The work that the leaf spring governor can do in moving a valve was discussed in detail, as well as the four valve engine design, using a slide valve for the admission, and Corliss valves for the exhaust. Other papers presented were: Efficient Advertising of Machinery, Theodore Slade; a discussion of the papers by W. S. Landis, Some Problems of the Cement Industry, and Milling Cutters and their Efficiency, by A. L. DeLeeuw, Mem.Am.Soc.M.E. Prof. J. E. Tuthill gave a talk on The Value of History to the Engineer.

STEVENS INSTITUTE OF TECHNOLOGY

On April 25, the Stevens Institute of Technology Student Branch held its closing meeting of the year. A. E. Bauhan was elected president of the society for next year; R. T. Branch, vice-president; A. D. Karr, secretary and O. E. Röesen, treasurer. The paper of the evening was Rotary Converter Sub-Station by A. E. Bauhan. Among the points treated were the growth and development of the sub-station, its location and requirements, its economic features and general layout, its specific layout to meet local conditions and demands, and a detailed description of the apparatus. The paper was discussed by Messrs. Mitchill, Requa, Schaefer and Stern.

UNIVERSITY OF CINCINNATI

On April 28 at a meeting of the University of Cincinnati Student Branch, papers on Alternating Current vs. Direct Current, by H. B. Cook, and Scientific Time Setting, by G. W. Binns, were presented. A general discussion by the members followed the reading of each paper.

UNIVERSITY OF MISSOURI

At the April 19 meeting of the University of Missouri Student Branch two papers published by the Society were presented and discussed: Commercial Application of the Turbo-Compressor, R. H. Rice and The Purchase of Coal, D. T. Randall. Professors Hib-

bard, Mem.Am.Soc.M.E., and Fessenden, Jun.Am.Soc.M.E., Messrs. Kennedy and Thacher discussed the papers. On May 1, the paper by S. B. Fowler, The Mechanical Handling of Freight, was read. The following took part in the discussion: Professors Hibbard Fessenden, Wharton, Westcott and Messrs. Thacher, Edgar, Dunbar.

UNIVERSITY OF WISCONSIN

At a meeting of the University of Wisconsin Student Branch, May 11, a paper on The Constructing Engineer was presented by Mr. Reed, formerly constructing engineer with the Arnold Company, Chicago, Ill. R. S. Hoyt also presented a paper, The Engineer, in which the aims, ideals, work and standards of the profession were considered.

YALE UNIVERSITY

A meeting of the Yale University Student Branch was held May 12 and a paper on The Essential Requirements as to Sewage Disposal, by George W. Fuller was presented. The paper touched on the nature of sewage, its relation to public water supplies, requirements for satisfactory disposal works, need of careful management, the hygienic, financial and sentimental aspect of the problem.

REPORT OF COMMITTEE ON IDENTIFICATION OF POWER HOUSE PIPING

a In the main engine rooms of plants which are well lighted, and where the functions of the exposed pipes are obvious, all pipes shall be painted to conform to the color scheme of the room; and if it is desirable to distinguish pipe systems, colors shall be used only on flanges and on valve fitting flanges.

b In all other parts of the plant, such as boiler house, basements, etc., all pipes (exclusive of valves, flanges and fittings), except the fire system, shall be painted black, or some other single, plain, durable, inexpensive color.

c All fire lines (suction and discharge), including pipe lines, valve flanges and fittings, shall be painted red throughout.

d The edges of all flanges, fittings or valve flanges on pipe lines larger than 4 in. inside diameter, and the entire fittings, valves and flanges on lines 4 in. inside diameter and smaller, shall be painted the following distinguishing colors, numbered 1 to 12, inclusive:

DISTINGUISHING COLORS TO BE USED ON VALVES, FLANGES AND FITTINGS ONLY

Steam division	*a*	High pressure—white
	b	Exhaust system—buff
Water division	*c*	Fresh water, low pressure—blue
	d	Fresh water, high pressure boiler feed lines—blue and white
	e	Salt water piping—green
Oil division	*f*	Delivery and discharge—brass or bronze yellow
Pneumatic division	*g*	All pipes—gray
Gas division	*h*	City lighting service—aluminum
	i	Gas engine service—black, red flanges
Fuel oil division	*j*	All piping—black
Refrigerating system	*k*	White and green stripes alternately on flanges and fittings, body of pipe being black
Electric lines and feeders	*l*	Black and red stripes alternately on flanges and fittings, body of pipe being black

Respectfully submitted,

F. R. HUTTON — H. P. NORTON

I. E. MOULTROP — J. T. WHITTLESEY

H. G. STOTT, *Chairman*

NECROLOGY

ALEXANDER E. BROWN

Alexander E. Brown was born in Cleveland, December 14, 1852, and was educated at grammar and high schools there. He was graduated from the Brooklyn Polytechnic Institute in 1872 as a civil engineer. Immediately after graduation Mr. Brown joined the U. S. Geological Survey under F. P. Haven. Until November 1872 he was engaged in the exploration and location of the Yellowstone National Park. During the next two years he served as chief engineer of the Massillon Iron Bridge Company, Massillon, O., where he obtained his first real experience in the iron business. From 1875 to 1879 he was engaged in bridge and building construction as engineer, designer and contractor. He later acted as superintendent at iron mines in the Lake Superior iron region and gained experience also in blast furnace work. In 1875 he invented and patented new machines and processes for annealing malleable iron castings, which are still in use at the National Malleable Iron Castings Company. In 1878 Mr. Brown became mechanical engineer for the Brush Electric Company then known as the Cleveland Electric Supply Company. While with this concern he developed the process and method of manufacturing light carbons. Still later he worked with Chas. F. Brush in developing and placing on the market the Brush arc lighting system. In 1879, Mr. Brown took up the problem of the rapid and economical unloading and handling of iron ore from boats. A year later he took out patents on the Brown hoisting and conveying machines erected on the docks of the N. Y., P. & O. Ry. Co., now part of the Erie system. He then organized the Brown Hoisting and Conveying Machinery Company for the manufacture of his machines. For the past 30 years Mr. Brown spent most of his time designing and manufacturing machinery for the handling of different machines. He had taken out several hundred patents on his various inventions.

He took an active interest in the development of trade schools in Cleveland, and was one of the directors of the Training School Company, organized in 1885, to open a carpenter shop for boys to which pupils were to be admitted free for a course extending over three years. He was a member of the American Institute of Mining Engineers, the Society of Naval Architects and Marine Engineers, Civil Engineers Club, Electric Engineers Club of Cleveland, the Engineers Club of New York and the Chamber of Commerce of Cleveland. He died April 26, 1911.

ON THE CONTROL OF SURGES IN WATER CONDUITS

By W. F. Durand

ABSTRACT OF PAPER

The usual treatment of the problem of the surge chamber presupposes a cylindrical form. Certain cases may arise in which a flaring or funnel-shaped form may rather be preferred. In any case the differential equations which indicate the movement of the water do not admit of direct mathematical solution. In consequence, various indirect and approximate methods have been devised. In all such, however, the point of departure has been an assumed size of chamber and a consequent determination of the resulting movement of the water. In the present paper the order is reversed. A program is imposed on the water and a surge chamber is found suitable for the realization of these imposed conditions. Taken in this order, the equations by the use of methods of approximate integration and differentiation admit of direct solution without trial and error adjustment. This method is described and illustrated in operative detail, with appendices giving the necessary mathematical discussion.

The relations between the characteristics of the acceleration curve for the water and the resulting form and dimensions of the chamber are discussed in detail and methods are developed for the rapid derivation of a series of chambers from a single type acceleration curve; also, for the determination of a chamber of such form and size as shall produce a non-oscillatory movement of the water in the chamber. Illustrative cases with graphical representation of the quantities involved are given in Appendix No. 3.

O.K.

ON THE CONTROL OF SURGES IN WATER CONDUITS

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Member of the Society

The literature of the problem of the surge chamber as a means of control of surges in water conduits has recently been enriched by two important papers presented before the Society, one by Raymond D. Johnson[1] and another by William F. Uhl,[2] in the latter case the treatment of the surge chamber being incidental to its relation to the general problem of speed regulation.

2 The attention of the writer has been directed recently to the examination of certain cases of surge-chamber design in which funnel or tapering forms rather than cylindrical forms are indicated by the environment and conditions of the problem. This has led to the re-examination of the various methods of treatment available, and to the development of a method by which, without prohibitive labor, the approximations of the various analytical and empirical methods may be avoided and a chamber determined of any desired degree of taper and suited to the development of any desired program as to rate of acceleration and amplitude of surge.

3 In connection with Fig. 1, let us assume the following notations:

v = velocity in general in conduit AB, assumed here of uniform cross-section area
v_1 = initial velocity for period under consideration
v_2 = velocity when movement of water level reaches first maximum
v_3 = velocity for ultimate steady conditions
v^1 = velocity such that v^1A = volume of water demanded by wheels under governor control for constant power during period under consideration

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[1] Trans. Am. Soc. M. E., vol. 30, p. 443.

[2] The Journal Am. Soc. M. E., February 1911, p. 169.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

A = cross-section area of conduit
F = cross-section area of surge chamber at water level
$n = \frac{F}{A}$
L = length of conduit AB
y = distance of water level in surge chamber from initial position for steady motion with velocity v_1
Y = distance of water level in surge chamber from static level
$a = \frac{L}{g}$
b = factor such that bv^2 = sum of friction and velocity heads at B; then $Y = y + bv_1^2$ for demanded load
and
$Y = 2y + bv_2^2$ for rejected load
H = gross head at wheels
h = total head involved in friction and acceleration
C = coefficient in Chezy formula[1]
r = hydraulic mean radius of conduit

4 In practice h will be of the form

$$h = fv^2 + h_0 + a\frac{dv}{dt}$$

where f = the value of $\frac{L}{C^2r}$ in the Chezy formula, v = the velocity in AB, h_0 = the sensibly constant friction loss for the part of the conduit or penstock lying between the surge chamber and the wheels, computed by the same formula and with a velocity corresponding sensibly to v_2 in AB and $a\frac{dv}{dt}$ = acceleration head. For rejected load $a\frac{dv}{dt}$ becomes negative and is therefore subtractive from the sum of $fv^2 + h_0$.

5 It should be noted that we shall here use the term "surge" not in the sense of the total or maximum movement of water during a period of changing load, but rather as the maximum distance by which the water level passes beyond its final location for steady conditions with the corresponding ultimate velocity.

6 In Appendix No. 1 it is shown that the differential equations for the movement of the water in the conduit and surge chamber are as follows:

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[1]Friction head = $\frac{Lv^2}{C^2r}$

$$\text{Demanded Load} \ldots\ldots \begin{cases} a\dfrac{dv}{dt} = y - b(v^2 - v_1^2) & \ldots\ldots\ldots\ldots\ldots\ldots [1] \\ n\dfrac{dy}{dt} = (v^1 - v) & \ldots\ldots\ldots\ldots\ldots\ldots [2] \end{cases}$$

$$\text{Rejected Load} \ldots\ldots \begin{cases} a\dfrac{dv}{dt} = y - b\,(v_1^2 - v^2) & \ldots\ldots\ldots\ldots\ldots\ldots [3] \\ n\dfrac{dy}{dt} = (v - v^1) & \ldots\ldots\ldots\ldots\ldots\ldots [4] \end{cases}$$

7 For constant power during the period of change, equal to that under steady conditions with the velocity v_3, we shall also have:

$$v^1 (H - h) = v_3 (H - h_3) \quad \ldots\ldots\ldots\ldots\ldots\ldots [5]$$

or

$$v^1 = v_3 \frac{H - h_3}{H - h} \quad \ldots\ldots\ldots\ldots\ldots\ldots [6]$$

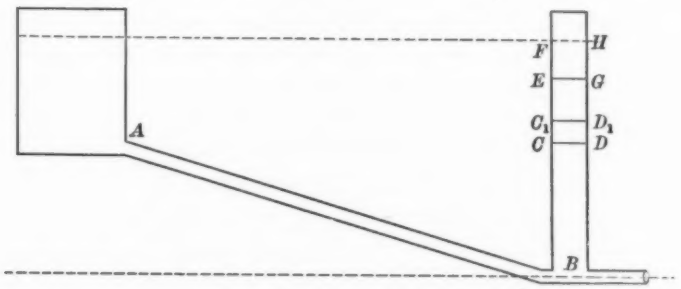

FIG. 1 DIAGRAM SHOWING ARRANGEMENT OF CONDUIT AND SURGE CHAMBER

EG denotes level for steady motion with velocity v_1
C_1D_1 denotes level for steady motion with velocity v
CD denotes actual level with velocity v
$EC = y$
$FC = Y$

8 These equations in effect represent a damped oscillation in which the damping force varies with the square of the velocity. In this form they have not been integrated, nor do they seem susceptible of integration, at least in terms of present known functions.

9 Under these circumstances, several courses are open as follows:

a The omission of the frictional or damping term and of the influence due to governor control. This is equivalent to taking $b = o$ and $v^1 = v_3$. This simplifies the problem to such a degree that it is readily treated by

exact mathematical methods. Such results have been developed many times and discussed by various authors. The assumed condition is, however, so far removed from the actual that the results are of small value except as a first step in the approach to the real problem.

b The substitution of a damping force varying as the first power of the velocity instead of as the square. This with suitable assumptions regarding the influence due to governor control makes possible the integration of the equation and renders the treatment similar to that for certain types of electrical oscillations. This substitution lies at the foundation of the masterly analytical treatment of the problem by certain eminent European engineers.[1] At the best, however, this method is approximate and must needs be under control by reference to some more exact method in order to know the order of error involved or to determine values of arbitrary constants.

c The development of approximate and empirical equations upon the various assumptions involving more or less simplification of the original equations, and involving the use of empirical coefficients derived from actual cases by means of method *d*. The paper by Johnson above referred to, with the accompanying discussion, furnishes a large number of such formulae developed either by the original author or by the authors of the discussion, and by means of which most problems within the field of control may be very satisfactorily treated. By the field of control is here meant the field over which are scattered the actual cases worked out by more exact methods and the results of which have been used to check the coefficients and results in general for the various approximate equations.

d The equations may be treated by approximate numerical integration in a step-by-step trial and error process. It will be obvious that by an appropriate procedure the equations may be treated by this general method whether n is constant or variable so long as the proposed form of chamber is specified.

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[1]Prasil, Wasserschloss probleme—Schweizer Bauzeitung—Band 52 Nr 21, 23, 24, 25.

10 In the methods of treatment indicated under *a*, *b* and *c*, it is of course, assumed that n is a constant. The more general assumption that n is a variable, that is, that the chamber may be of conical or vase-like form, would require the expression of n as a function of y. This would result in the general case in a further complication which would render still more difficult or impossible the treatment of the problem on the assumptions made in *a*, *b* and *c*.

11 In the literature of the present subject many illustrations[1] of method *d* for constant n will be found in the annals of the Society as well as in other engineering and scientific works. The writer has done, perhaps, a fair share of the tedious work involved in the application of this method, and it was in a measure as a revolt against this

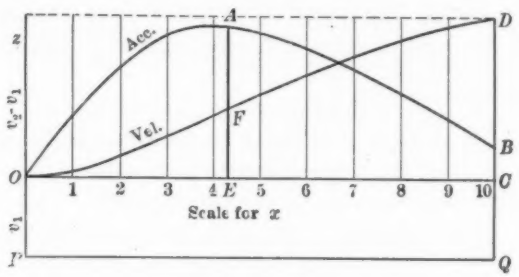

FIG. 2 DIAGRAM SHOWING RELATION OF ACCELERATION AND VELOCITY CURVES ON TIME AXIS

serious expense of time, that the method which forms the subject of the present paper was developed.

12 In all of the preceding methods whether by analytical approximation or by numerical integration, the method of approach to the problem is as follows: Given a specified or proposed surge chamber, what will happen? Let us reverse the order and state the question thus: Given a program for the water, required a surge chamber to produce it.

13 To develop the possibilities of this viewpoint, let us fix in advance the character of the acceleration of the water in the conduit as indicated by the curve *OAB* in Fig. 2, in which diagram time is laid off on the x-axis, but without as yet any determination of scale; and acceleration is laid off on the z-axis without as yet any determination of scale.

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[1]The Surge Tank in Water-Power Plants, R. D. Johnson, Trans. Am. Soc. M. E., vol. 30, p. 443.

14 The curve OAB is then taken as the proposed history of the acceleration up to the time when the water reaches its highest or lowest level, according as the case is for rejected or demanded load. In order to fix the ideas, we shall for the present assume the case of demanded load and a falling surface of water. Then the acceleration curve OAB and the time OC both relate to the period from the start to the attainment of a maximum drop of water surface or to a maximum value of y. The plotting of this curve does, therefore, nothing more than to fix in advance the general type or form of the acceleration curve, leaving all questions of actual numerical values for later determination. Methods for the determination of the scale factors and the numerical values will be found in Appendix No. 2. In order not to interrupt the continuity of development of the general method, the question of scales may be waived for the moment and we may assume OAB to represent definitely the time history of the acceleration $\frac{dv}{dt}$.

15 By means of a planimeter, or by arithmetical means, or by an integraph, if such an instrument should be available, the first integral curve of OAB is readily found as shown by OD. This will give the time history of the change in velocity from v_1 to v_2. Lay off v_1 as OP and draw PQ. Then from PQ as an axis the curve OD will give the complete time history of the velocity in its growth from $PO = v_1$ to $QD = v_2$.

16 Now, writing equations [1], [2] and [5], we have

$$a\frac{dv}{dt} = y - b(v^2 - v_1^2) \quad \ldots\ldots\ldots\ldots\ldots\ldots [7]$$

$$n\frac{dy}{dt} = (v^1 - v) \quad \ldots\ldots\ldots\ldots\ldots\ldots [8]$$

$$v^1 = v_2\frac{H - h_2}{H - h} \quad \ldots\ldots\ldots\ldots\ldots\ldots [9]$$

In equation [7], it is readily seen that we now know all quantities except y. Hence, by direct substitution, we find y for a series of values of the time, and if desired we may plot the result as a curve of y on time.

17 This curve is indicated in Fig. 3 by OAB. Let CA denote the level for steady conditions with the final velocity v_2, then $OC = b(p_2^2 - v_1^2)$, while CD denotes the extent of the surge or drop below CA, the final level for steady conditions. We next proceed to differentiate

the curve OAB. This may most easily be done by numerical methods as given in Appendix No. 1. At any given point, or value of the time, this will give the value of $\frac{dy}{dt}$. We may also find v^1 from [9], and thus in [8] we have all quantities known except n, which may be found by the solution of this equation.

18 The time histories of all quantities, $\frac{dv}{dt}$, v, y and n, are now known. We may as desired, plot $a\frac{dv}{dt}$, v and n on y and in particular may reduce n to the diameter of the chamber and plot on y, thus showing for the chamber the form and dimensions required. In case the influence of governor control is omitted, we may put $v^1 = v_2$ in [8] and discard [9]. This will simplify the operations to a considerable degree.

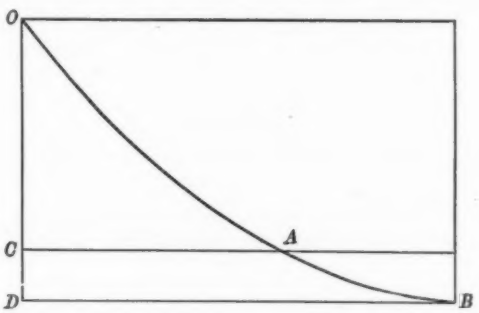

FIG. 3 DIAGRAM SHOWING MOVEMENT OF WATER LEVEL ON TIME AXIS

19 The time required for the complete treatment of a given case by this method might be from two to four hours, depending on the number of points found, the degree of accuracy required, etc. The aid of a slide rule of the Fuller or Thatcher form and giving a fifth place by estimation is assumed.

20 After a given case has been worked through for a single value of the time, a second case with a different value of the time and the same acceleration curve, except for slight modifications near the end, may be worked through with considerable saving of time. In this manner, a series of forms of the chamber may readily be derived from a single base or type curve of acceleration.

21 After the area of the acceleration curve has been found, the areas of the chamber at the top and near the bottom or at the top, near the bottom and at one or two intermediate points may quickly be found, and independently of the detailed determination of the

curve of y as described in Par. 16. In this manner the general character of the chamber may be readily foreseen in advance of the complete and detailed determination of its form. The resulting value of y_{max} and hence the amount of surge may also be found immediately and in advance of the detailed determination of the y curve or of the form of the chamber. The general characteristics of the acceleration curve may also be readily adjusted to produce a chamber of any desired general character of form and size.

22 In Appendix No. 2 will be found further discussion of these details of the operative program, together with the numerical work for a typical case, the latter indicating in detail the various steps. A study of this form of computation together with the fundamental equations, will better serve to acquaint the reader with the operative details of the method than further descriptive treatment.

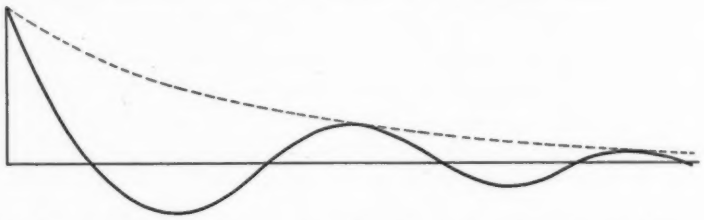

FIG. 4 DIAGRAM ILLUSTRATING OSCILLATORY AND NON-OSCILLATORY MOVEMENTS

NON-OSCILLATORY MOVEMENT

23 One special case merits particular attention. The movement of the water surface has been referred to as that of a damped oscillation. The peculiar characteristic of such a movement lies in the fact that it involves a continuous and indefinite approach to a final level or condition or axis by means of an indefinite series of swings or oscillations of decreasing amplitude and lying on either side of the final level, or axis, and as represented by the full line in Fig. 4.

24 Now the limiting case of such a movement is that of a single swing or indefinite approach to the final level or condition or axis, but without passing beyond, and lying wholly on one side of such a final goal. Such a movement is indicated by the dotted line in Fig. 4. This condition has its direct analogy in certain types of electrical non-oscillatory discharge.

25 Now in the case of a hydraulic conduit with surge chamber, the realization of a non-oscillatory movement of the water in the chamber may well be considered as a most desirable ideal in case the

needed dimensions are practicable. The dimensions and form of such a chamber are readily determined by the choice of an appropriate form of acceleration curve combined with a suitable time allowance.

26 It is clear when the water reaches its final level that in all cases we must have simultaneously the velocity $\frac{dy}{dt}$ and the acceleration $\frac{dv}{dt}$ equal to zero. This results from the form of the y curve which is here coincident with the axis. If this final condition is to be realized by a non-oscillatory movement, then the one swing of the water surface which represents the passage from the initial level to its maximum drop and the simultaneous change of velocity from v_1 to v_3 must be conditioned by a suitable form of acceleration curve. Obviously, this will be a curve of the form indicated in Fig. 5, where

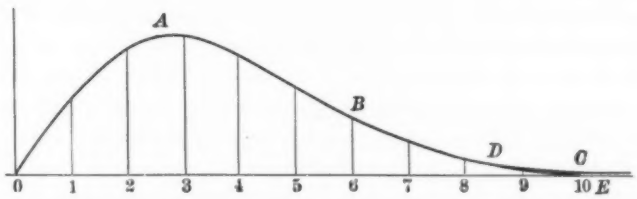

FIG. 5 DIAGRAM SHOWING TYPE OF ACCELERATION CURVE FOR NON-OSCILLATORY MOVEMENT

$OABC$ indefinitely approaches x and the value of the acceleration indefinitely decreases as time increases. Theoretically, we should realize the final conditions only after an infinite time.

27 Practically two courses are open:

a A form of curve $OABC$ where the terminal point C lies near but not quite on the x-axis is assumed. In other words, a finite part of the indefinitely extended curve is used implying for the conditions when y reaches its first maximum value, a slight residual acceleration, and hence a slight surge or movement of the water surface beyond its level for steady conditions. By taking C near the axis this surge may be reduced to an entirely insignificant value, and the resulting movement thus made sensibly non-oscillatory. In such a case the mode of procedure is the same as for the general case.

b A form of curve $OABDE$ in which the curve is brought down tangent to x within a finite distance is assumed.

In the general case with an acceleration curve of the form shown in Fig. 2 or *OABC*, Fig. 5, it is shown in Appendix No. 2 that there is but one particular value of the time which will fit the various conditions imposed, and the time thus determined is therefore that required for the first swing to a maximum value of y.

28 In case, however, the curve is assumed of the form *OABDE*, it is shown that the time is not determined by the conditions thus imposed, and in consequence we are free to choose any value of the time whatever, as long as it does not fall below a certain limiting minimum. For each value of the time which may thus be taken, a corresponding chamber will result suitable for the realization of the proposed program of acceleration, non-oscillatory movement of the water, etc., and all within the assumed time. In this manner a series of chambers may be developed from one assumed base curve of acceleration, the required work for all cases after the first being comparatively small. An illustrative case with further discussion of operative details will be found in Appendix No. 3.

RELATIONS BETWEEN FORM OF ACCELERATION CURVE AND CHARACTERISTICS OF CHAMBER

29 Regarding the selection of a form of acceleration curve which will correspond to any proposed general form of chamber a very little experience with the treatment of such problems serves to show the general type of acceleration curve produced by chambers of cylindrical or tapering form. The value of the acceleration starting at zero mounts rapidly to a maximum during the early part of the total period, and then falls off more gradually to its value for $v = v_2$, either zero or some relatively small value, as shown in Figs. 2 and 5, according as it is intended to have the movement non-oscillatory or to permit a small surge movement. It may also be readily seen in what manner the form of the curve should be modified in order to produce any desired change in the amount of surge, the time required or the general form of the resulting chamber.

30 A further important question in the case of non-oscillatory movement refers to the relation between the change in the time allowed and the resulting change in the form of the chamber, the form of the acceleration curve remaining the same.

31 In Appendix No. 2 will be found a detailed discussion of these points including the development of such relations as will

provide for the ready adjustment of a curve of acceleration suited to develop any general form of chamber as desired, and to secure any specified program as regards the movement of the water, permissible extent of surge, time required, etc.

THE RELATION BETWEEN DEMANDED AND REJECTED LOAD

32 The general discussion of this method of treatment has assumed the condition of demanded load where any differences were involved. It is evident that precisely the same methods may be applied to the case of rejected load. The latter investigation may be of special importance in connection with the permissible height of surge in case a moderate surge may be permitted. It will scarcely be necessary to discuss this case in detail, or to develop the special forms which the various equations will take.

33 An examination of the various equations for this case will show that for a given program of acceleration, etc., a chamber of different form and in general of smaller capacity will be required than for the case of demanded load. Or otherwise with a given chamber, the program of water movement, extent of surge, etc., will be somewhat less than for the case of demanded load. It follows therefore, in the case of substantially non-oscillatory movement in particular, that a chamber developed to secure this character of movement for demanded load, will in a still higher degree secure the same result for rejected load.

34 It is, of course, evident that a chamber developed for the case of demanded load will not, in the case of rejected load, give the same program of acceleration, etc. The acceleration at the start with tapering chamber will be more abrupt and the acceleration curve will be steeper, the range of values, however, running less than for the case of demanded load.

35 If for a chamber developed for the case of demanded load it is desired to determine the detailed results in the case of rejected load, there seems to be no more direct method than the regular solution of the equations for this case by means of approximate integration and trial and error adjustment.

SOURCE AND CHARACTER OF ERRORS

36 The degree of accuracy which may be expected in the solution of problems of this character, together with the sources of uncertainty

or error merit brief notice. Errors in the final results may arise from four chief causes:

a The failure of the general equations properly to include all the factors or conditions of the problem.

b The adoption of approximate methods of treatment involving the omission of various factors or the simplification of their relations to the problems, all for the purpose of bringing the equations or the resulting conditions within the range of ready mathematical treatment.

c Uncertainty regarding the values to be ascribed to various empirical constants.

d The inaccuracies of numerical computation.

37 In the case of the present problem, errors of class *a* may arise from the failure of the governor to work perfectly, and from a slight change in the efficiency of the wheels with change in effective head and hence in spouting velocity. These conditions will affect the virtual velocity v^1 and hence in any given case the actual values of v^1 may not be equal exactly to those given by equation [6].

38 In no actual case furthermore, does the load remain perfectly constant. In many cases it may remain sensibly constant, while in some the governor will be continually chasing the conditions developed by the load, but never quite overtaking or controlling them. Assuming, however, for the sake of definiteness of condition that the load is uniform and that the velocity v^1 is properly given by [6], it appears that all remaining conditions with the exceptions noted in Par. 39 are properly represented in the general equations.

39 The influence of acoustic waves and their time element are not included in the fundamental equations as developed. There is good reason for such omission in the fact that the time element introduced by the acoustic wave is small compared with the time involved in the rise and fall of water in a surge chamber, and no sensible error will result from such omission in dealing with surge chamber problems. On the other hand, as is well known, the time element introduced by the acoustic wave must be considered in the general problem of governor control.

40 Errors of class *b* are necessarily present in all analytical treatments of the present problem. The present method eliminates errors of this class.

41 Errors of class *c* in the proposed method of treatment depend solely on the value of the coefficient for loss of head due to friction.

It will be noted that the coefficient b in the general equations is the only one which involves empirical constants of this character.

42 Errors of class d are wholly under control. They may be reduced to any desired limit by a suitable adjustment of the program of numerical computation.

43 It follows in the proposed method of treatment, assuming the conditions of the problem to be properly represented by the general equations, that the only source of unavoidable error lies in the coefficient for friction loss. The results therefore, when derived by the aid of adequate methods of numerical computation, must represent the consequences of the assumed conditions with the same degree of accuracy as that with which we may compute the final effective head, the horsepower with an assumed wheel efficiency, or any other simple result for which the friction head is a determining factor.

APPENDIX NO. 1

GENERAL EQUATIONS OF MOTION FOR THE CASE OF A CONDUIT MADE UP OF SECTIONS OF DIFFERENT SIZES AND HENCE CONTAINING COLUMNS OF WATER MOVING AT DIFFERENT VELOCITIES.

44 The general equations for the motion of the water in a pipe line of uniform cross-section under the influence of a surge chamber have been so frequently derived and are so well known in the literature of the subject that their derivation as a special case may be omitted.

45 It not infrequently occurs, however, that the conduit as a whole is made up of sections of different sizes and lengths and hence at any instant contains columns of water of varying weights and moving with different velocities. The usual equations of motion which are based on an assumed uniform section, and hence uniformity of velocity throughout the conduit, cannot be used for this case. It therefore becomes of practical importance to determine the more general equations for this case.

46 Referring to Fig. 6 we shall use the following notation:

A, A_b, A_c to denote areas of sections a, b, c

u, v_b, v_c to denote velocities in sections a, b, c

It will be noted that the conditions in section a are to be taken as standard, and hence the area and velocity for this section are denoted by A and u without a special subscript.

u_1 = initial velocity in section a

u_2 = velocity in section a when movement of water level reaches first maximum

u_3 = velocity in section a for ultimate steady conditions

m = ratio between velocity in any section and that in section a, that is

$$v_b = m_b u$$
$$v_c = m_c u, \text{ etc.}$$

Hence, we shall have

$$A_b = \frac{A}{m_b}$$

$$A_c = \frac{A}{m_c}$$

V = volume of 1 lb. of water

σ = density

C = coefficient in Chezy formula

r = hydraulic mean radius

u^1 = velocity in section a which would carry just the volume of water demanded by the wheels when under governor control during the period under consideration

h = total lost head between intake of conduit and wheels

Then h = friction head + acceleration head

H = gross head at W

F = area of surge chamber at water level

$$n = \frac{F}{A}$$

y = movement of water level in surge chamber from position for steady motion with velocity u_1

Y = movement of water level in surge chamber from static level

47 To fix the ideas we shall assume the condition of demanded load and hence of increasing velocity, and write the general equation of work-energy for 1 lb. of water entering the conduit at B and passing out at E.[1] We shall take

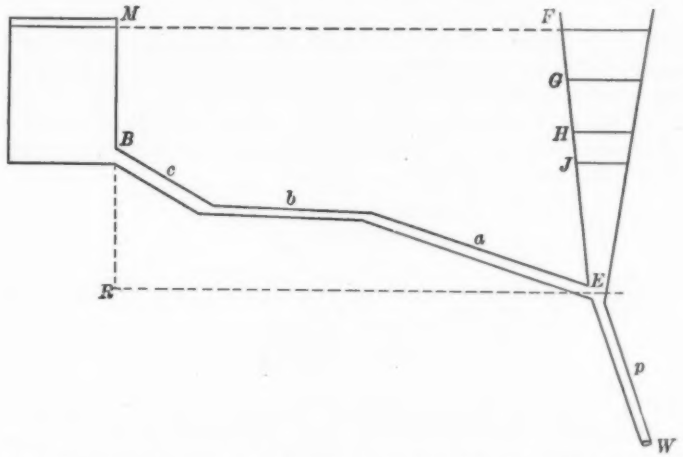

FIG. 6 DIAGRAM SHOWING CONDUIT LINE OF MIXED SIZES WITH SURGE CHAMBER

F denotes level for static conditions
G denotes level for steady conditions with velocity u_1 in section *a*
H denotes level for steady conditions with velocity u in section *a*
J denotes level for actual conditions with velocity v in section *a*

the datum level at E since only the parts of the system lying above this datum are directly involved. At the point B we shall have the following items of work-energy inflow:

$$\frac{v_0^2}{2g} = \text{kinetic energy}$$

Head BR = potential energy

$$P_B V = \frac{P_B}{\sigma} = \text{work done on entering pound of water}$$

These constitute the total work-energy input at B.

[1]The influence due to entrance head at the intake of the conduit is omitted as usually too small to be of significance.

48 Corresponding and equal to this total input, we have a threefold subdivision as follows:

a A part is represented by the work required to overcome frictional resistance in the conduit.

b A part is represented by increase in the kinetic energy of the water in the conduit which is undergoing continuous acceleration and hence is increasing in energy content.

c The remainder is represented by the work-energy output at the point *E*.

Taking first the work required to overcome the skin friction in the conduit, we have for any section of length L, hydraulic radius r, coefficient C and velocity v.

$$\text{loss of head}^1 = \frac{v^2 L}{C^2 r}$$

49 This is commonly called loss of head. It is readily seen that in effect it is the measure of the work required to overcome the frictional resistance throughout a conduit of length L per lb. of water entering or leaving, or in general per lb. of water flowing past any given section. In the present case all quantities are taken per lb. of water so that for any section in general, we shall have for the work expended in friction,

$$\text{work} = \frac{v^2 L}{C^2 r}$$

For the entire conduit made up of sections of mixed sizes, we shall have

$$\text{work} = \Sigma \left(\frac{v^2 L}{C^2 r} \right)$$

where Σ denotes simply the summation of the series of partial amounts for each individual section of the total conduit. But, in general $v = mu$ and hence

$$\text{work} = \Sigma \left(\frac{v^2 L}{C^2 r} \right) = u^2 \Sigma \left(\frac{m^2}{C^2 r} \right)$$

50 We have next for the kinetic energy in any section of the conduit,

$$\text{energy} = K = \frac{\sigma A L v^2}{2g}$$

Then in time dt this is subject to change (in the present case increase) by the amount

$$dK = \frac{\sigma A L v}{g} \times \frac{dv}{dt} dt$$

Now for 1 lb. to enter at B or to pass E or in general to pass any given point, the time is

$$dt = \frac{1}{\sigma A v}$$

---

[1]This follows directly from the Chezy formula.

Substituting this value of dt in the above value of dK we have

$$dK = \frac{Ldv}{gd_t}$$

Hence the total amount of energy absorbed in the acceleration of the contents of the entire conduit will be

$$\Sigma dK = \Sigma \left(\frac{Ldv}{gdt} \right)$$

But since in general $v = mu$, we have

$$\frac{dv}{dt} = m \frac{du}{dt}$$

and

$$\Sigma dK = \Sigma \left(\frac{Ldv}{gdt} \right) = \frac{du}{dt} \Sigma \left(\frac{mL}{g} \right)$$

51 Finally, at the point of exit E, we have the following items of work-energy output

$$\frac{u^2}{2g} = \text{kinetic energy}$$

$$P_E V = \frac{P_E}{\sigma} = \text{work done on outgoing lb. of water}$$

Hence, collecting and equating we have

$$\frac{v^2}{2g} + BR + \frac{P_B}{\sigma} = u^2 \Sigma \left(\frac{m^2 L}{C^2 r} \right) + \Sigma \left(\frac{mL}{g} \right) \frac{du}{dt} + \frac{u^2}{2g} + \frac{P_E}{\sigma} \quad \ldots\ldots [10]$$

But

$$\Sigma \frac{v^2 L}{C^2 r} = u^2 \Sigma \left(\frac{m^2 L}{C^2 r} \right) = \text{total friction head}$$

Hence

$$u^2 \left[\Sigma \left(\frac{m^2 L}{C^2 r} \right) + \frac{1}{2g} \right] = FH$$

Also

$$\frac{P_E}{\sigma} = JE$$

Hence [10] is eqivalent to

$$MR = FH + JE + \Sigma \left(\frac{mL}{g} \right) \frac{du}{dt}$$

or

$$\Sigma \left(\frac{mL}{g} \right) \frac{du}{dt} = MR - (FH + JE) = HJ \quad \ldots\ldots [11]$$

But

$$HJ = y - GH$$

and

$$GH = FH - FG = \begin{cases} \text{difference of total friction and velocity} \\ \text{heads for velocities } u_1 \text{ and } u \end{cases}$$

Hence, we have

$$GH = \left[\Sigma\left(\frac{m^2L}{C^2r}\right) + \frac{1}{2g}\right](u^2 - u_1^2)$$

and [11] becomes

$$\Sigma\left(\frac{mL}{g}\right)\frac{du}{dt} = y - \left[\Sigma\left(\frac{m^2L}{C^2r}\right) + \frac{1}{2g}\right](u^2 - u_1^2) \quad \ldots\ldots\ldots\ldots [12]$$

It thus appears that in such a conduit with mixed sizes the virtual or equivalent length in the term involving acceleration is $\Sigma\, mL$ while in the term involving friction the virtual term $\frac{L}{C^2r}$ is $\Sigma\left(\frac{m^2L}{C_2r}\right)$

52 In accordance with the preceding notation, the amount of water required at any given instant during the period of change is u^1A. The amount which is coming through section a of the conduit is uA. Hence, assuming $u^1 > u$ the remainder must come from the surge chamber. In general, we shall have

$$u^1A = uA + F\frac{dy}{dt}$$

or

$$\frac{Fdy}{Adt} = n\frac{dy}{dt} = (u^1 - u) \quad \ldots\ldots\ldots\ldots\ldots\ldots [13]$$

Also h = friction head plus acceleration head or

$$h = \Sigma\left(\frac{m^2L}{C^2r}\right)u^2 + \Sigma\left(\frac{mL}{g}\right)\frac{du}{dt} + h_0 \quad \ldots\ldots\ldots\ldots [13]_1$$

where h_0 represents the sensibly constant friction loss in the section of the conduit between the surge chamber and the wheels, and which may be based on a sensibly uniform velocity corresponding to u_3 in section a. Frequently this term h_0 will vanish. Then for constant power during the period under consideration we shall have

$$u^1A\,(H - h) = u_3A\,(H - h_3)$$

Hence

$$u^1 = u_3\frac{(H - h_3)}{(H - h)} \quad \ldots\ldots\ldots\ldots\ldots\ldots [14]$$

53 It is evident that the total friction head as a part of h and h_3 must be found by summing the friction heads for the various parts of the entire line including the penstock p. It should also be noted that the pipe p is carrying the total volume of water while the conduit abc is carrying only a part. The velocities in these various sections must therefore be taken accordingly. No sensible error will be involved if the velocity in p is taken as uniform and of such value as to correspond to u_3 in section a. Rewriting [12], [13] and [14] to bring them together, we have

$$\Sigma\left(\frac{mL}{g}\right)\frac{du}{dt} = y - \left[\Sigma\left(\frac{m^2L}{C^2r}\right) + \frac{1}{2g}\right](u^2 - u_1^2) \quad \ldots\ldots [15]$$

$$n\frac{dy}{dt} = \left(u^1 - u\right) \quad \ldots\ldots [16]$$

$$u^1 = u_3\frac{(H - h_3)}{(H - h)} \quad \ldots\ldots [17]$$

54 If the conduit is of uniform section then m becomes 1 in all cases and putting L the length of the conduit for ΣmL and Σm^2L and writing now v instead of u, we have

$$\frac{L}{g}\frac{dv}{dt} = y - \left(\frac{L}{C^2r} + \frac{1}{2g}\right)\left(v^2 - v_1^2\right) \quad \ldots\ldots [18]$$

55 Equations [16] and [17] remain the same in form for this case as for the more general. If we neglect the influence due to governor control and assume that the flow of water is uniform in volume and equal to u_3A then u^1 becomes u_3 and equation [17] may be discarded.

56 A comparison of equations [15] and [18] shows, as might be expected, that the equation for a conduit with mixed sizes is similar in form to that with uniform size, but with different coefficients for the terms involving acceleration and friction. It also appears that by using the velocity and acceleration in some one section as standard, the case with mixed sizes may be thus reduced to an equivalent or virtual case with uniform size.

57 The preceding various equations in the form given apply to the case of demanded load. For the case of rejected load the modifications are readily made. The resulting equations are

$$\Sigma\left(\frac{mL}{g}\right)\frac{du}{dt} = y - \left[\Sigma\left(\frac{m^2L}{C^2r}\right) + \frac{1}{2g}\right](u_1^2 - u^2) \quad \ldots\ldots [19]$$

$$n\frac{dy}{dt} = (u - u^1) \quad \ldots\ldots [20]$$

$$u^1 = u_3\frac{(H - h_3)}{(H - h)} \quad \ldots\ldots [21]$$

$$h = \Sigma\left(\frac{m^2L}{C^2r}\right)u^2 - \Sigma\left(\frac{mL}{g}\right)\frac{du}{dt} + h_0 \quad \ldots\ldots [21]_1$$

APPENDIX NO. 2

THE DERIVATION OF SCALE RATIOS AND NUMERICAL RELATIONS FOR ANY GIVEN ACCELERATION CURVE

58 Repeating Fig. 2, the following notation will be used:

x to denote the abscissa
z to denote the ordinate
α to denote the scale ratio for z
β to denote the scale ratio for x
R to denote the area of acceleration curve $OABC$

Then for the acceleration corresponding to any point on the curve, we have

$$\frac{dv}{dt} = \alpha z$$

For the time, we have

$$T = \beta x$$

or otherwise β is the value of the time interval or unit adopted for x.

59 From equations [1], [2] and [6] we have

$$y = a\frac{dv}{dt} + b\,(v^2 - v_1^2) \quad \ldots\ldots [22]$$

$$\frac{dy}{dt} = \frac{v^1 - v}{n} \quad \ldots\ldots [23]$$

$$v^1 = v_2\frac{H - h_3}{H - h} \quad \ldots\ldots [24]$$

Differentiating [22], we have

$$\frac{dy}{dt} = a\frac{d^2v}{dt^2} + 2bv\frac{dv}{dt} \quad \ldots\ldots [25]$$

Whence from [23] and [25]

$$\frac{v^1 - v}{n} = a\frac{d^2v}{dt^2} + 2bv\frac{dv}{dt} \quad \ldots\ldots [26]$$

60 At the end of the period under consideration both v^1 and v become v_2. Hence $v^1 - v = 0$ and we must have as a necessary condition at the end of such period

$$a\frac{d^2v}{dt^2} = -2bv_2\frac{dv}{dt} \quad \ldots\ldots [27]$$

But referring to the assumed curve of acceleration, we have

$$\left.\begin{aligned} \frac{dv}{dt} &= \alpha z \\ \text{and} \qquad \frac{d^2v}{dt^2} &= \alpha \frac{dz}{dt} = \frac{\alpha}{\beta}\frac{dz}{dx} \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots [28]$$

Hence, substituting these values in [27], we have

$$\frac{a\alpha}{\beta}\frac{dz}{dx} = -2bv_2\alpha z$$

Whence

$$\frac{\frac{dz}{dx}}{z} = -\frac{2bv_2\beta}{a}$$

Putting $\frac{dz}{dx} = m$ and solving for β we have

$$\beta = \frac{-am}{2bv_2 z} \quad \ldots\ldots\ldots\ldots\ldots\ldots [29]$$

61 It thus appears that the general equations involve a relation which takes such form where y becomes a maximum at the end of the period (and hence at the terminal end of the acceleration curve), as to provide for the determination of the time scale β and hence of the time T which will be required on the program resulting from the acceleration curve assumed. In other words, the curve as assumed, in conjunction with the constants a, b and the final velocity v_2 will admit of but one value of the time, and hence one value of the time scale β as determined by [29].

62 Again from the relations involved we have

$$\alpha\beta R = \text{total change in velocity} = (v_2 - v_1)$$

whence

$$\alpha\beta = \frac{v_2 - v_1}{R} \quad \ldots\ldots\ldots\ldots\ldots\ldots [30]$$

and

$$\alpha = \frac{v_2 - v_1}{R\beta} \quad \ldots\ldots\ldots\ldots\ldots\ldots [31]$$

It remains to determine v_2. The actual relations of v_2 and h_2 are, however, implicit, and hence a value of v_2 must be found by trial which will result in satisfying equations [29] and [30] above and also the following:

$$h_2 = fv_2^2 + h_0 + a\frac{dv}{dt}$$

$$\frac{dv}{dt} = \alpha z$$

$$v_2 = \frac{v_2(H - h_2)}{H - h_2}$$

For demanded load, v_2 will slightly exceed v_3. Often the difference will be too small to be of significance. In any case, the value is readily found by trial substitution in the above equations.

63 Likewise in general, change of velocity for any period of time equals area of corresponding part of acceleration curve multiplied by $\alpha\beta$ or

$$\Delta v = \frac{v_2 - v_1}{R} \int \frac{dz}{dx} dx \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [32]$$

That is, at any point as E the change of velocity will equal $\alpha\beta \times$ area OAE. Let OFD be the integral curve of OAB, that is, a curve such that any ordinate EF is proportional to the area OAE. Then ordinates similar to EF represent areas similar to OA, and it follows that in order to transform the ordinates of OFD into velocity changes we have only to multiply by the value of $\alpha\beta$ as found in [29]. Likewise, if we multiply the ordinates of the acceleration curve OAB by α we shall have the corresponding value of the actual acceleration $\frac{dv}{dt}$. From equation [22] we are now able to derive the values of y and to plot them if desired.

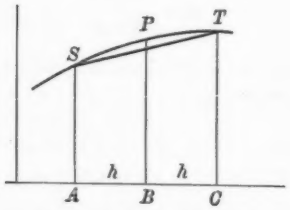

FIG. 7 DIAGRAM SHOWING METHOD OF FINDING TANGENT LINE TO A GIVEN CURVE

64 To derive the values of $\frac{dy}{dt}$ we proceed as follows: In Fig. 7 let SPT be an arc of any curve for which AS, BP and CT are three consecutive ordinates separated by equal spaces K. Then it is well known that for a second-degree parabola[1] passing through S, P and T the tangent at the point P is parallel to the chord ST. Now if the points S and T are not too far removed from P, a second-degree parabola will lie very close to the actual curve, and the tangent to the parabola at P will lie very close to the tangent to the given curve at the same point. That is, under the circumstances specified, it is clear that the two curves at P will have sensibly the same direction and hence the tangent found in this manner will give a good approximation to the true value. Hence, if we denote the ordinates by subscripts 1, 2, 3, we shall have

$$\left(\frac{dy}{dt}\right)_2 = \frac{y_3 - y_1}{2h} \quad \ldots\ldots\ldots\ldots\ldots\ldots [33]$$

[1]Mathematical Treatment of Continuous Functions by Approximate Methods, Sibley Journal of Engineering, January 1894.

This gives a numerical method for finding $\frac{dy}{dt}$ for the curve of y on time at all except the first and last points.

65 For points such as S and T (Fig. 7) it has been shown[1] that the values of $\frac{dy}{dt}$ for the second-degree parabola are as follows:

$$\left(\frac{dy}{dt}\right)_1 = \frac{4y_2 - 3y_1 - y_3}{2h} \quad \ldots\ldots [34]$$

$$\left(\frac{dy}{dt}\right)_3 = \frac{y_1 + 3y_3 - 4y_2}{2h} \quad \ldots\ldots [35]$$

66 Instead of the preceding method of finding values of $\frac{dy}{dt}$ involving the numerical differentiation of the y curve, we may utilize [25] giving:

$$\frac{dy}{dt} = \left(\frac{a\alpha}{\beta}\right)\frac{dz}{dx} + 2\alpha bvz$$

or

$$\frac{dy}{dt} = \alpha\left(\frac{adz}{\beta dx} + 2bvz\right) \quad \ldots\ldots [36]$$

The determination of $\frac{dy}{dt}$ in this manner involves the differentiation of the z or acceleration curve instead of the y curve, and may in certain cases be the more useful mode of procedure. In particular, it permits of finding the value of n for any point on the z curve in advance of the work required to determine the values of y.

67 This method permits therefore, in particular, the determination, independently of y, of the size of the chamber at the top and near the bottom and at one of two intermediate points as desired, thus indicating the general size and character of the chamber which a given acceleration curve will produce. To this end from [23] we write

$$n = \frac{v^1 - v}{\alpha\left(\frac{a}{\beta}\frac{dy}{dx} + 2bvz\right)} = \left(\frac{R\beta}{v_2 - v_1}\right)\frac{v^1 - v}{\left(\frac{a}{\beta}\frac{dz}{dx} + 2bvz\right)} \quad \ldots\ldots [37]$$

68 At the initial instant when time = 0, we have

$$v^1 = v_1\frac{H - h_2}{H - h_1}$$

$$v = v_1$$

$$z = 0$$

[1] Mathematical Treatment of Continuous Functions by Approximate Methods, Sibley Journal of Engineering, January 1894.

Hence at the point for $T = 0$ we have

$$n_0 = \frac{v^1 - v_1}{\frac{a\alpha}{\beta}\frac{dy}{dx}} = \left(\frac{R\beta^2}{v_2 - v_1}\right)\frac{v^1 - v}{a\frac{dz}{dx}} \quad \ldots\ldots\ldots\ldots\ldots\ldots [38]$$

The value of $\frac{dz}{dx}$ is to be found as in [34] and then by substitution in [38] the value of n for the point where $y = 0$ is immediately found. A numerical example of these computations will be found in Appendix No. 3

69 If the influence of governor control is neglected, $v^1 = v_2$ continuously and the equations become somewhat simplified as follows: For the value of n at any given point we have from [37]

$$n = \frac{v_3 - v}{\alpha\left(\frac{a}{\beta}\frac{dz}{dx} + 2bvz\right)} = \left(\frac{R\beta}{v_3 - v_1}\right)\frac{v_3 - v}{\frac{a}{\beta}\frac{dz}{dx} + 2bvz} \quad \ldots\ldots\ldots [39]$$

For the value of n at the beginning of the period when $z = 0$ and $v = v_1$ we have

$$n_0 = \frac{R\beta^2}{a\frac{dz}{dx}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [40]$$

In equations such as [36], [37], [39] the algebraic sign of $\frac{dz}{dx}$ must be carefully noted.

70 It is seen that at the end of the period both $(v^1 - v)$ and $\frac{dy}{dt}$ become zero together, so that the value for this point becomes indeterminate. By the usual mathematical methods, the expression for n at this point may be evaluated and the resulting value of n found. In general, however, this will be quite unnecessary since the methods previously given provide for the determination of the size for any point as near the end as may be desired. Thus the determination of the size for the point where $x = 9$ on a scale of 10 will in general give a value sufficiently near for any possible practical purpose.

MAXIMUM VALUE OF y

Amount of Surge

71 The maximum value of y will be, of course, the value for the close of the period and when $v^1 = v = v_2$. Substitution in [22] gives

$$y = a\left(\frac{dv}{dt}\right) + b\ (v_2^2 - v_1^2)$$

72 The movement for ultimate steady conditions is $b\ (v_2^2 - v_1^2)$. The difference will be the surge. Hence we have

$$\text{Surge} = a\frac{dv}{dt} + b\,(v_2^2 - v_1^2) \quad \ldots\ldots\ldots\ldots\ldots\ldots [41]$$

or again substituting for $\frac{dv}{dt}$ we have

$$\text{Surge} = a\alpha z + b(v_2^2 - v_1^2) \quad \ldots\ldots\ldots\ldots\ldots\ldots [42]$$

The value of z used in [42] must, of course, be that for the close of the period or at the terminal end of the acceleration curve. The amount of surge may therefore be computed from [41] or [42], or inversely the characteristics of the acceleration curve may be adjusted in such manner as to secure a surge of any specified limiting value.

DETERMINATION OF SCALE RATIOS AND NUMERICAL RELATIONS FOR THE CASE OF NON-OSCILLATORY MOVEMENT

73 If the curve of acceleration for non-oscillatory movement is taken as $OABC$ (Fig. 5), then the program of operation is exactly the same as that for any curve in general, and as already described. It should be especially noted, however, that in order to insure the conditions for a vanishing value of the surge, the relation between the values of z_{10} and $\left(\frac{dz}{dx}\right)_{10}$ must be adjusted so as to give a large value of β. This is apparent from [41] or [42]. By appropriate adjustment, therefore, the conditions may be determined so as to produce a surge of 0.5 ft., 0.1 ft. or any other value which may be considered negligible.

74 In case, however, the curve of acceleration is taken as $OABDE$, then at the point of coincidence with the axis of x we have $z = 0$ and $\frac{dz}{dx} = 0$ or otherwise $\frac{1}{a\alpha}\frac{dv}{dt} = 0$ and $\frac{\beta}{a\alpha}\frac{d^2v}{dt^2} = 0$ [28]. Hence, referring to [25], it appears that $\frac{dy}{dt}$ at this point will become zero independent of the values of β and α or in other words, for all values of β and α. It results that we are free in this case to choose β at will. The outline of the procedure is therefore as follows.

75 The area is found as in the previous case. As before

$$\alpha\beta = \frac{v_3 - v_1}{R}.$$

Assuming β at will, gives

$$\alpha = \frac{v_3 - v_1}{R\beta}$$

We then proceed in exactly the same manner as before with the determination of the various quantities, resulting in the ultimate determination of the values of

n and of the size and form of the chamber. The value of y_{max} in this case is always

$$y_{max} = b\ (v_3^2 - v_1^2)$$

and equals the fall of water to the level for steady conditions for velocity = v_3. The value of the surge is of course zero by condition. The value of n for $T = 0$ is given by [38] as in the more general case. The value of n for the end of the period is indefinite as in the general case. This, however, is a matter of no significance since the dimensions and form of the chamber are sufficiently determined otherwise.

76 For varying values of β it is evident that since the area of the acceleration curve R remains the same, the value of $\alpha\beta$ will remain unchanged, and hence the entire history of the velocity in its change from v_1 to v_3. Also it is evident that α will vary inversely as β. Hence in the value of y, as given in [22], the term

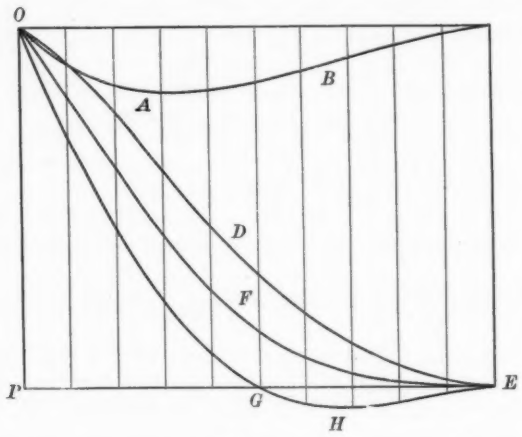

FIG. 8 DIAGRAM ILLUSTRATING METHOD OF FINDING MINIMUM CHAMBER FOR NON-OSCILLATORY MOVEMENT

$a\dfrac{dv}{dt}$ or $a\alpha z$ is the only one undergoing change, and this varies directly as α or inversely as β. Hence for example if β be doubled the values of $a\dfrac{dv}{dt}$ will be halved and the new values may be therefore immediately written from the old. The values of v^1 also remain the same and hence of $v^1 - v$. Hence for a determination of the form of chamber corresponding to a new value of β a part only of the entire program of computation is required, and a series of chambers corresponding to a series of values of β may therefore be quickly derived, once the results for a single case are in hand. At the initial level the area of the chamber will vary as β^2 as in the more general case and as shown by [38].

77 The value for n for an intermediate point is also readily found by the use of [37]. In this expression β is the only term which changes its value and hence for a given intermediate value of v we may find the value of $\dfrac{dz}{dx}$ once for all and then find a series of values of the ratio n. By the use of these direct methods values of n for the initial level and for two other points, one near the middle

and one near the end of the period, may be quickly found for a wide range of values of β. The values of y for such intermediate points are then found from [22] and such values of y and n together with those for the initial level will serve to determine the character of the chambers in general terms.

DETERMINATION OF MINIMUM CHAMBER FOR NON-OSCILLATORY MOVEMENT OF THE WATER

78 While it is true that with a form of acceleration curve such as $OABDE$ the equations may be fulfilled for any value of β or any value of the time allowed, yet the case will fail physically if the time is too short. The conditions determining such limit may be investigated as follows: Rewriting equation [22] we have

$$y = a\frac{dv}{dt} + b\,(v^2 - v_1^2)$$

or

$$y = a\alpha z + b\,(v^2 - v_1^2)$$

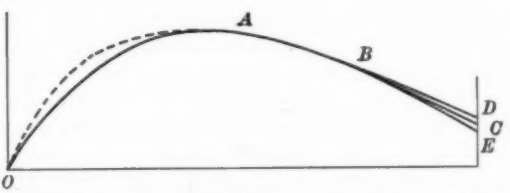

FIG. 9 DIAGRAM ILLUSTRATING RELATION BETWEEN FORM OF CHAMBER AND CHARACTERISTICS OF ACCELERATION CURVE

79 Now plotting separately each of the two terms of the value of y and taking y positive downward, it is seen (Fig. 8) that they are of the forms indicated by $OABC$ for $a\alpha z$ and ODE for $b\,(v^2 - v_1^2)$. In each case the curves have a horizontal tangent at the end of the period, and hence their sum, the curve of y will have a horizontal tangent at the same point, as is required for a maximum or minimum value.

80 Now change of β results in leaving the curve ODE the same, but in changing the scale of $OABC$. Hence with a large value of β and therefore a small value of α and a correspondingly small value of the ordinates of $a\alpha z = a\dfrac{dv}{dt}$ we shall have a curve of y somewhat as indicated by the line OFE in which, as shown, the water level sinks somewhat rapidly at first and then more and more slowly until it finally settles to E, reaching at this point its maximum value. Suppose, however, the value of β reduced to half its value for this case. Then the ordinates of $OABC$ will be multiplied by two and adding such increased values to ODE, we shall have a result somewhat as in $OGHE$, where as seen, the curve cuts the level PE at G, drops below to a maximum at H and again rises through a point of inflexion to a minimum at E. But

$$OP = b\,(v_2^2 - v_1^2)$$

Hence at the point G we have

$$y = a\frac{dv}{dt} + b\,(v^2 - v_1^2) = b\,(v_2^2 - v_1^2)$$

and since $\frac{dv}{dt} = \alpha z$, we find

$$a\alpha z = b\,(v_2^2 - v^2)$$

Substituting from [31] for α and solving for β

$$\beta = \frac{az\,(v_2 - v_1)}{bR\,(v_2^2 - v^2)} \qquad [43]$$

81 Now if we take the values of z and v corresponding to a point very near the end of the curve, say where $x = 9$ on a scale of 10, we shall find the value of β which would cause the y curve to dip across the line PE at this point. Some such value may be taken as the minimum value of β consistent with a substantial fulfilment of the condition of no surge.

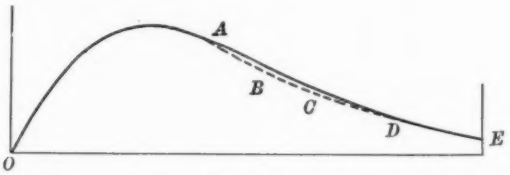

FIG. 10 DIAGRAM ILLUSTRATING RELATION BETWEEN FORM OF CHAMBER AND CHARACTERISTICS OF ACCELERATION CURVE

82 The crossing of the y curve below PE and its later return upward while the velocity is still increasing toward its value v_2 represents an impossible set of physical conditions and the method of computation if carried forward would give an impossible form of chamber. Hence if we employ with the given acceleration curve a limiting value of β found as suggested in Par. 79, it will produce down to the level PE a form of chamber consistent with the physical conditions and which will drop the water level to PE at a time equal to 9β, for example. If the chamber is then continued down as conditions may require and of substantially the same area, it will mean simply a chamber in which the specified conditions of the acceleration curve at the end of the period would be imperfectly fulfilled, and in which there might result an infinitesimal surge. Such chamber would, however, practically fulfil all requirements for determining a movement of the water substantially non-oscillatory, and might be taken as the smallest with which such conditions could be secured, at least on the basis of the assumed acceleration curve.

RELATION BETWEEN FORM OF ACCELERATION AND FORM AND DIMENSION OF CHAMBER

83 Suppose the assumed acceleration curve to be $OABC$. Let the value of β be determined from [29]. Consider the result of slight modification at the end as indicated at BD or BE. For BD the value of z_{10} is increased and

that of m, the tangent of the slope, is decreased. Hence β will be decreased. For BE the changes are in the reverse direction and the value of β will be increased. By a little trial adjustment the form of the curve may be so modified as to give within limits any desired value of β.

84 If now we suppose the form of chamber corresponding to the curve OAC to be determined, then it is evident that the areas $OABD$ and $OABE$ will differ but slightly from $OABC$. Hence to a first approximation R and $\alpha\beta$ in [30] and [31] will remain the same while α will vary inversely as β. It will result that the values of v and hence of $b\ (v^2 - v_1^2)$ will remain sensibly the same and hence that the change in the values of y, equation [22], will be determined by the change in the term $a\dfrac{dv}{dt} = a\alpha z$.

85 The new value of the surge, [41] or [42], is also quickly found as well as the values of n for the beginning and one or two other points on the curve by [37] and [38]. If these indications justify, the form and dimensions of the chamber may then be developed in detail by the regular treatment of the new curve $OABE$ or $OABD$.

86 Referring further to the area at the level for $T = 0$ it appears from [38] that in such a case the value of n will vary directly as β^2 and hence for chambers of similar forms corresponding dimensions will vary directly as β. The resulting change in area or diameter of chamber at the level where $T = 0$ is thus apparent. If it is desired to hold the upper diameter or area within some specified limits, the slope of the curve may be correspondingly modified. Thus, if the change is in the direction BE the result will be an increase in the values of β and of the diameter of chamber where $T = 0$, both sensibly in the same ratio. If at the same time, however, the slope of the curve at the origin is increased, as indicated by the dotted line, this latter modification will serve to counteract more or less the change due to varying β and hence by adjustment between the two any specified or limiting value of this diameter may be determined.

87 By the aid of [30], [31], [32], [33] the general results of any small modification in the form of the acceleration curve may be analyzed, showing the character of change in the form of the chamber. Thus, in Fig. 10, let the original curve indicated by the full line be modified as indicated by the dotted line. For the purposes of such an analysis the new curve may be divided into the following parts:

OA and DE remaining the same as before
AB with increased negative slope and decreased ordinate
BC with the same slope sensibly and decreased ordinate
CD with decreased negative slope and decreased ordinate.

88 The analysis need not be given in detail. Having in view the direction and relative quantitative amounts of change in the various quantities involved, the changes in the area of chamber will be as follows:

Period Corresponding to	*Change in Area of Chamber*
OA	decrease
AB	from decrease to small and uncertain and then increase
BC	increase
CD	from increase to small and uncertain
DE	small and uncertain

89 There are many other minor points of relationship between the form of the curve of acceleration and the resulting form of the chamber, the amount of surge, the characteristics of the movement of the water, etc., which will occur to anyone dealing with actual problems, but which are scarcely of sufficient importance to warrant further detailed notice. It results, however, that the acceleration curve may by such means be quickly and readily adjusted to develop within limits a chamber of any desired general character of form, and to fulfil any predetermined or specified program as regards the movement of the water surface, extent of surge and time required.

APPENDIX NO. 3

ILLUSTRATIVE CASES

90 Two or three illustrative cases may be drawn from the problem which has given rise to the development of this particular method. This problem is concerned with the control of the water in the Los Angeles aqueduct at one of the power sites where the principal conditions are as follows:

91 The water is to be led through a cement lined rock tunnel a distance of about 41,000 ft. to the power drop whence a penstock of about 3150 ft. in length will lead to the power house. The upper portal of the tunnel is under a positive head varying with the stage of the reservoir but which may be taken at 85 ft. maximum. The total drop through the tunnels is 58.8 ft., made up of two gradients, 26,800 ft. for the first section on a gradient of 0.001 and 14,100 ft. for the second section on a gradient of 0.0023. The fall at the power drop is 808 ft. and the total gross head is 808 + 58.8 + 85 = 951.8 or 952 ft.

92 The maximum amount of water to be handled is 1000 cu. ft. per sec. and the actual amount will be in accordance with the momentary power demand

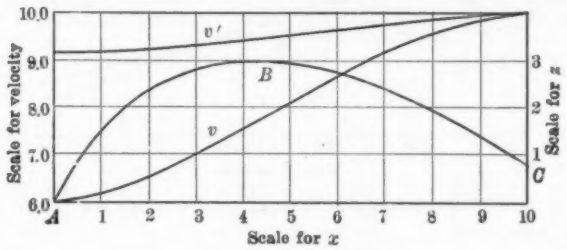

FIG. 11 DIAGRAM SHOWING TYPE CURVE OF ACCELERATION WITH RESULTING VELOCITIES PLOTTED ON TIME

up to this value as a maximum. The two sections of the tunnel are not of the same size, and the velocities of flow will therefore not be equal. For purposes of preliminary study, however, a uniform conduit of 100 sq. ft. section was assumed, thus giving a maximum velocity of 10 ft. per sec. It thus appears that under maximum conditions the tunnel as a whole will contain some 128.125 tons of water, which moving at a velocity of 10 ft. per sec. would have a kinetic energy of 200,000 foot-tons in round numbers. Again, it appears from computations which need not be here repeated that without the aid of a surge chamber in developing an acceleration head the time of acceleration from a flow of 600 cu. ft. per sec. to 990 cu. ft. per sec. when 1000 ft. are called for would be some 40 to 50 seconds. To relieve the conditions which would result from the acceleration or retardation in this manner of the 7.76 miles of water column during periods of change for both demanded and rejected load, a surge chamber of cement lined rock excavation, preferably of conical or vase-like form, is contemplated at the end of the lower tunnel and at the top of the power drop.

93 Many alternative studies have been made for this chamber based on a variety of operative conditions. Certain of the preliminary studies based on an assumed uniform section of tunnel may be here used for illustrative purposes.

CASE 1

94 For the numerical coefficients $a = \frac{L}{g}$ and b we have in the present case

$$a = 1285$$
$$b = 1.2$$

also

$$v_1 = 6.0$$
$$v_2 = 10.0$$

For the friction head

$$h_f = \left(1.2 - \frac{1}{2g}\right)v^2 + .20 = 1.1844\,v^2 + 20$$

also

$$H = 950$$

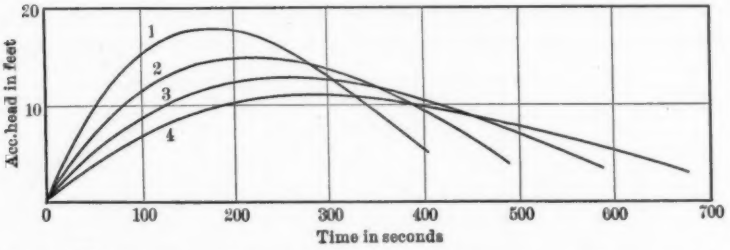

FIG. 12 DIAGRAM SHOWING ACCELERATION PLOTTED ON TIME FOR FOUR DIFFERENT CASES

(1) Acc. head for $\beta = 40.70$
(2) Acc. head for $\beta = 48.95$
(3) Acc. head for $\beta = 58.80$
(4) Acc. head for $\beta = 68.80$

95 For the type curve of acceleration the curve ABC (Fig. 11), was assumed. The numerical values of the ordinates, which we may denote by z, are given in column 2 of Table 1, the scale being entirely arbitrary and these numbers at present having no physical meaning. The assumed curve is first integrated by any of the well known methods and the resulting values placed in column 3. Trapezoidal integration has been used throughout in this preliminary work as will appear from an examination of the values. The total area is 21.415. This is the R of the formulae.

We next find $m = \frac{dz}{dx}$ at the end of the curve by the use of [35]

$$1.93 \times 1 = 1.93$$
$$1.39 \times 4 = 5.56$$
$$.75 \times 3 = 2.25$$

Then

$$1.93 + 2.25 = 4.18$$

and

$$4.18 - 5.56 = -1.38$$

The interval $h = 1$. Hence

$$m = -\frac{1.38}{2} = -0.69$$

TABLE 1 TABLE SHOWING TYPICAL FORM OF COMPUTATION

1	2	3	4	5	6	7	8	9
x	z		v	$v^2-v_1^2$	$b(v^2-v_1^2)$	$a\frac{dv}{dt}$	y	$2\frac{dy}{dx}$
0	0	0	6.000	0	0	0	0	18.100
1	1.47	0.735	6.139	1.688	2.026	7.320	9.346	19.284
2	2.36	2.650	6.502	6.276	7.531	11.753	19.284	20.263
3	2.83	5.245	6.995	12.930	15.516	14.093	29.609	20.804
4	3.00	8.160	7.547	20.957	25.148	14.940	40.088	20.828
5	2.95	11.135	8.111	29.788	35.746	14.691	50.437	19.953
6	2.73	13.975	8.644	38.705	46.446	13.595	60.041	18.331
7	2.38	16.530	9.134	47.430	56.916	11.852	68.768	15.630
8	1.93	18.685	9.542	55.050	66.060	9.611	75.671	11.560
9	1.39	20.345	9.858	61.180	73.416	6.912	80.328	6.404
10	0.75	21.415	10.060	65.200	78.240	3.730	81.970	0

	10	11	12	13	14	15	16
x	h	$H-h$	v^1	v^1-v	n	D	Y
0	62.64	887.36	9.145	3.145	17.02	45.39	43.20
1	71.96	878.04	9.242	3.103	15.76	43.67	52.55
2	81.82	868.18	9.348	2.846	13.75	40.79	62.48
3	92.05	857.95	9.460	2.465	11.60	37.47	72.81
4	102.40	847.60	9.575	2.028	9.53	33.96	83.29
5	112.61	837.39	9.691	1.580	7.75	30.62	93.64
6	122.07	827.93	9.802	1.158	6.18	27.35	103.24
7	130.67	819.33	9.905	0.771	4.83	24.18	111.97
8	137.45	812.55	9.988	0.446	3.78	21.38	118.87
9	142.01	807.99	10.044	0.186	2.84	18.54	123.53
10	143.59	806.41	10.060	0	.....	.....	125.18

96 We then find by trial, using the equations given in Appendix No. 2, the values $v_2 = 10.06$, $\beta = 48.95$ and $\alpha = 0.003873$. Hence, the total time for the period = 489.5 seconds = 8.16 minutes. The time required on the basis of the assumed curve is thus determined. We have, therefore,

$$\alpha\beta = \frac{v_2 - v_1}{R} = 0.1896$$

We next find by inserting the proper numerical values in [42]

$$\text{Surge} = 5.17$$

97 Taking the factor $\alpha\beta = 0.1896$ as explained in Appendix No. 2 and using it as a multiplier, we convert column 3 of Table 1 into velocity change, and

adding $v_1 = 6$ we have the velocity history on time as given in column 4. We then find values of $(v^2 - v_1^2)$ as in column 5 and multiplying by $b = 1.2$ we have values of $b\,(v^2 - v_1^2)$ as in column 6.

98 From the value α (Par. 96)

$$a\alpha = 1285 \times 0.003873 = 4.98$$

Using this as a factor, we convert column 2 into values of $a\,\frac{dv}{dt}$ as in column 7. We then add the values in columns 6 and 7 finding values of y and enter in column 8.

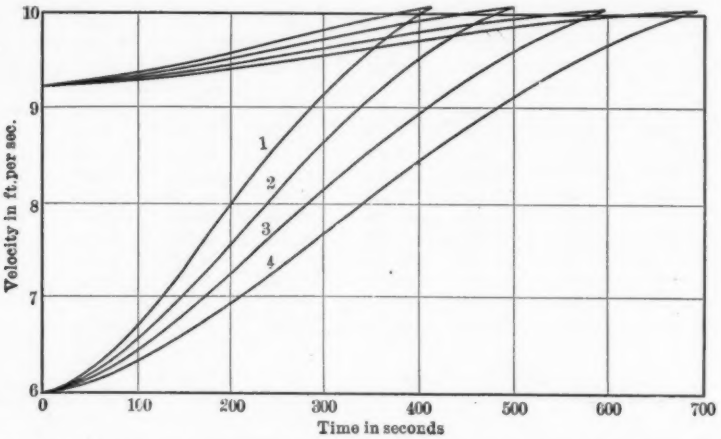

FIG. 13 DIAGRAM SHOWING VELOCITIES PLOTTED ON TIME FOR FOUR CASES AS IN FIG. 12

(1) Velocities v and v^1 for $\beta = 40.70$
(2) Velocities v and v^1 for $\beta = 48.95$
(3) Velocities v and v^1 for $\beta = 58.80$
(4) Velocities v and v^1 for $\beta = 68.80$

99 Next by the use of [33], values of $2\,\frac{dy}{dx}$ for the various points 0 - - - - 9, inclusive, are obtained and entered in column 9. Evidently

$$\frac{dy}{dt} = \frac{2\,\frac{dy}{dx}}{2\beta}$$

This division by $2\,\beta$ may be taken as a multiplication in the final operation for n as noted below.

100 We next find values of h by adding together values of the acceleration head, column 7, and of $h_f = 1.1844\,v^2 + 20$. These results are entered in column 10 and subtracting them from the gross head, taken here as 950, we have values of $(H - h)$ as in column 11. We then find values of the virtual velocity v^1 by equation [27], Appendix No. 2, and enter the results in column 12. Subtracting v (column 4) from these, we find values of $(v^1 - v)$ as in column 13. Dividing the values in column 13 by those in column 9 and multiplying by

$2\beta = 97.9$ we find values of n as in column 14. These converted into diameter of chamber give the values in column 15.

101 The upper diameter of 45.2 ft., it will be remembered, is for the water level corresponding to a steady velocity of 6 ft. per sec. This will be 43.2 ft. below static level. Hence, adding 43.2 to the values of y in column 8 we find values of Y the distance of the water surface below static level. These are given in column 16.

102 The principal results are shown graphically in Figs. 12, 13 and 14. The dotted line shows the surge chamber slope continued up to the static level

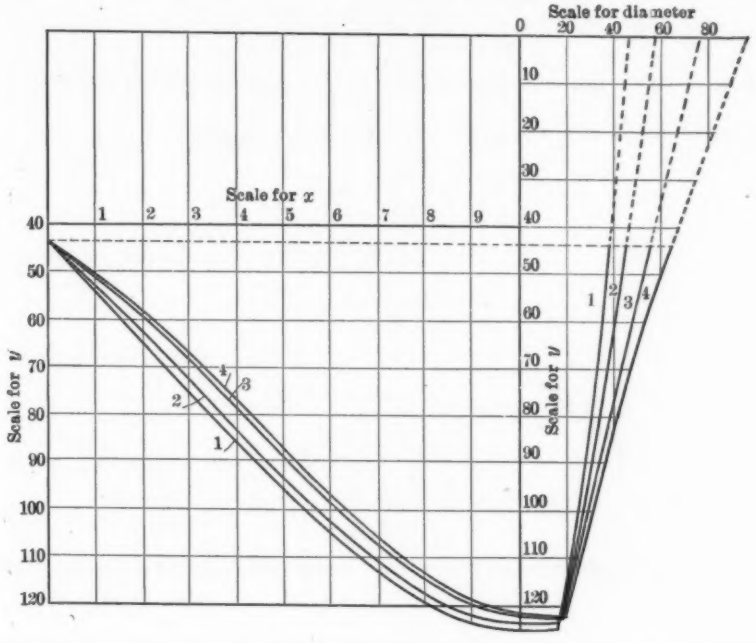

FIG. 14 DIAGRAM SHOWING VALUES OF y PLOTTED ON TIME AND PROFILES OF SURGE CHAMBERS FOR FOUR CASES AS IN FIG. 12

Curves 1 refer to case for $\beta = 40.70$
Curves 2 refer to case for $\beta = 48.95$
Curves 3 refer to case for $\beta = 58.80$
Curves 4 refer to case for $\beta = 68.80$

and indicates, therefore, the general dimensions as some 60 ft. in diameter at the top and 18 ft. at the bottom. Such a chamber then with its given dimensions between the level 43.2 and the bottom would determine for a change in velocity from 6 ft. per sec. to 10.06 ft. per sec., an acceleration and velocity history as indicated, and a maximum fall of water of 81.97 ft. below the level for 6 ft. per sec. steady conditions. This is 125.17 ft. below static level and 5.17 ft. below the level for 10 ft. per sec. steady flow. The surge is therefore 5.17 ft. as previously determined.

103 We may next illustrate the determination of the value of n for $x = 0$, $x = 3$ and $x = 9$ by the use of [37] and [38]. For $\left(\frac{dz}{dx}\right)_0$ we use [34], giving

$$\frac{dz}{dx} = 1.76$$

Then from [38] we have

$$n_0 = \frac{21.415 \times 2396.6 \times 3.145}{4.06 \times 1285 \times 1.76} = 17.35$$

and $D = 46.0$. Likewise for $x = 3$ we find $\frac{dz}{dx} = 0.32$ and substituting the values in [37] we find $n = 11.33$ and $D = 37$. For $x = 9$ we find

$$\frac{dz}{dx} = -0.59$$

$$n = 2.76$$

and

$$D = 18.3$$

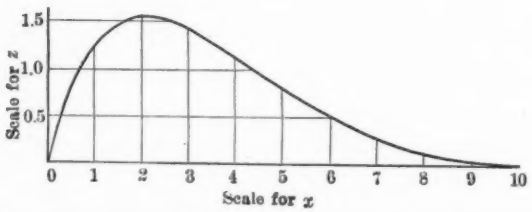

FIG. 15 DIAGRAM SHOWING TYPE CURVE FOR NON-OSCILLATORY MOVEMENT

104 These various results agree as well with those of Table 1 as could be expected considering the open spacing of ordinates and trapezoidal integration. With closer spacing of ordinates and the use of parabolic rules for integration the difference between the two sets of results will become a vanishing quantity.

105 Suppose next the end of the acceleration curve raised as shown by dotted lines giving to z values as follows:

$$z_8 = 1.95$$
$$z_9 = 1.45$$
$$z_{10} = 0.85$$

We then find

$$\left(\frac{dz}{dx}\right)_{10} = -0.65$$

and

$$\beta = 40.7 \text{ seconds}$$

106 We may assume that the values of R and of v_2 for the transformed curve will differ only slightly from the original values. This assumption will evidently involve no error of significant amount. We may then find immediately the surge from [41] or [42], thus

$$\text{Surge } 1285 \times 0.004658 \times 0.85 + 1.2 \times 1.2 = 6.53$$

107 In the same manner as for the original curve we find by [37] and [38] values of n for $x = 0$, $x = 3$, $x = 9$. For $x = 0$ it is evident from [38] that n varies as β^2.
Hence

$$n_0 = 17.35 \times \left(\frac{40.7}{48.95}\right)^2 = 12.03$$

$$D = 38.2$$

For $x = 3$ we find by substitution in [37]

$$n = 9.14$$
$$D = 33.3 \text{ ft.}$$

For $x = 9$ we have $\frac{dz}{dx} = -0.55$ and we find

$$n = 2.36$$
$$D = 16.9 \text{ ft.}$$

The new value of α will be:

$$\alpha = \frac{0.003873 \times 48.95}{40.7} = 0.004658$$

This will give for the new values of y

$$y_3 = 32.5$$
$$y_9 = 81.7$$

These results give an outline of the size and form of the resulting chamber in Fig. 14.

TABLE 2 PRINCIPAL RESULTS FOR FOUR CASES DERIVED FROM THE SAME TYPE ACCELERATION CURVE

	x_3	x_9	x_{10}	β	Time, Min.	Surge	D_0	D_3	D_9
Original Curve.....	1.93	1.39	0.75	48.95	8.16	5.17	46.0	37.0	18.3
Change 1.....	1.95	1.45	0.85	40.70	6.78	6.53	38.2	33.3	16.9
Change 2.....	1.91	1.35	0.67	58.80	9.80	4.21	55.4	41.2	19.5
Change 3.....	1.89	1.31	0.60	68.80	11.47	3.56	64.8	44.8	20.7

108 If the form of the acceleration curve near the end be slightly modified in the opposite direction, there will result for each change a new case, giving larger sized chambers and larger values of the time. The results of such changes may be determined in the same manner as outlined in Pars. 106 and Par. 107. The principal features for the original and for three changes in the acceleration curve are given in Table 2, and are shown graphically in Figs. 12, 13 and 14.

109 These results for the three changes are of course only approximations, since the change at the end will affect the total area slightly and hence the entire velocity history. The more exact values may of course be formed by going

TABLE 3 VALUES OF ORDINATES OF CURVE IN FIG. 15

x	z	x	z
0	0	5.5	0.55
0.5	0.80	6.0	0.42
1.0	1.22	6.5	0.30
1.5	1.44	7.0	0.22
2.0	1.50	7.5	0.16
2.5	1.44	8.0	0.12
3.0	1.30	8.5	0.08
3.5	1.14	9.0	0.04
4.0	0.98	9.5	0.01
4.5	0.83	10.0	0.
5.0	0.68	....	....

through the case in the regular manner. Assuming the change in the acceleration curve small, however, the errors will be small, and the values found in

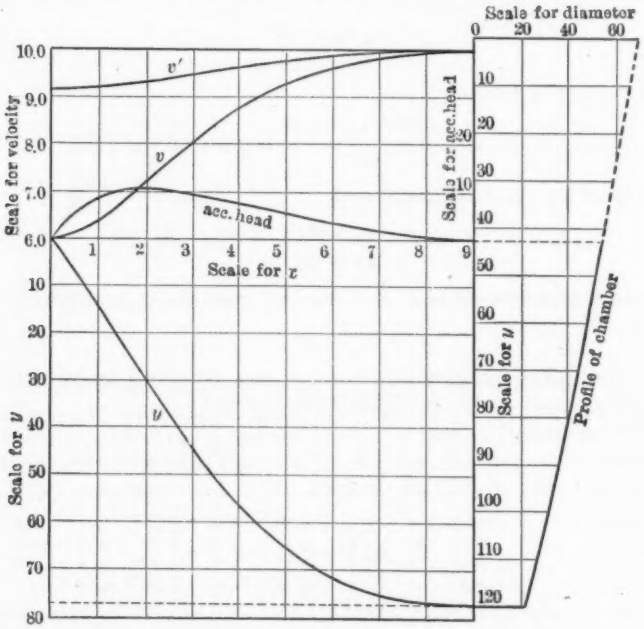

FIG. 16 DIAGRAM SHOWING GENERAL RESULTS FOR THE ACCELERATION CURVE OF FIG. 15

Curves showing results for case with vanishing value of surge. Value of $\beta = 102.8$.

Table 2 will give a closely approximate idea of the general results as to time, extent of surge and size and form of chamber.

Case 2

110 As an illustration of a case of practically non-oscillatory movement, reference may be made to the acceleration curve of Fig. 15 where the portion employed is that lying between $x = 0$ and $x = 9$. The value of the ordinates of this curve are given in Table 3.

111 The general method is exactly the same as for the preceding cases and need not be developed in detail. The principal results with the form and dimensions of the chamber and the graphical history of certain of the quantities are shown in Fig. 16.

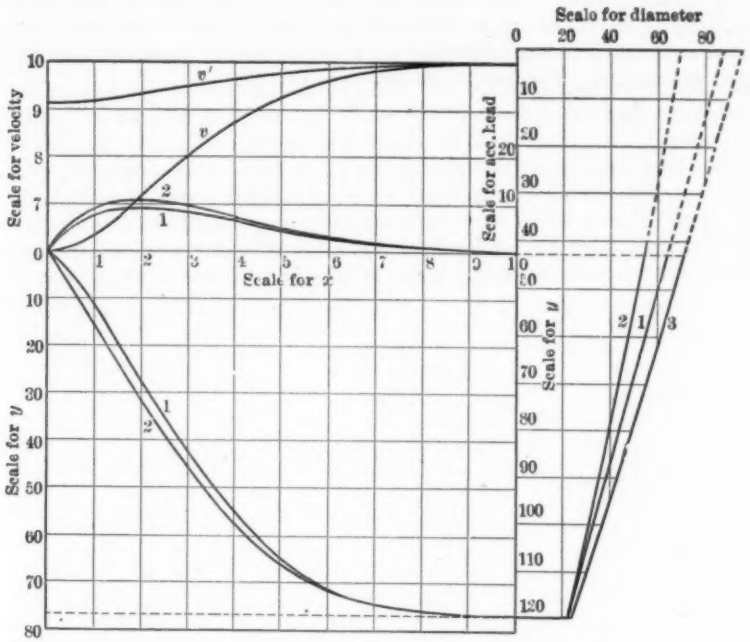

Fig 17 Diagram showing General Results for Non-Oscillatory Movement with Acceleration Curves as shown

Curves 1 refer to case for $\beta = 120$
Curves 2 refer to case for $\beta = 108$
Curves 3 refer to case for $\beta = 120$ and neglecting governor control

Case 3

112 If the entire extent of the curve in Fig. 17 be used, the value of β becomes indefinite as we have seen. If we assume $\beta = 120$ seconds, we may then work through the case as before. The results for such a case are shown graphically in Fig. 17. The time is 20 minutes and the surge is zero by condition.

113 In order to determine the minimum time and the minimum size of the chamber with which the surge, with this form of acceleration curve, may still be kept near the vanishing point, we substitute in [43] the values for the curve at $x = 9$ and find $\beta = 108$. This gives a time of 972 seconds or 16.2 minutes

within which the water level will descend 76.8 ft. while the velocity will rise from 6 ft. per sec. to 9.988 ft. per sec. This is a substantial fulfilment of the conditions as required. If the velocity goes on to 10 ft. per sec. the water level will fall below the level for steady motion with $v = 10$, and an infinitesimal surge will result. The form and dimensions of the chamber corresponding to this condition are shown in Fig. 17.

Case 4

114 This case is the same as Case 3 with $\beta = 120$ except for the omission of the governor control. The rate of penstock flow is taken as the equivalent of a velocity of 10 ft. per sec. in the main conduit throughout the entire period. The simplification in the numerical work will be readily apparent without detailed description. The results are shown in Fig. 17.

POWER AND HEAT DISTRIBUTION IN CEMENT MILLS

By L. L. Griffiths

ABSTRACT OF PAPER

A comparison is made in this paper of the methods used and the results obtained in five different cement plants for converting the thermal power of the fuel into productive mechanical work. A brief description is given, both of the power installation and of the mill arrangement; and the relative efficiencies of different raw materials, types of grinding machinery and engineering arrangements are considered. The data are such as to enable comparisons to be made between the same types of machinery, and in most cases, the same size and make of machinery, at least in individual departments, if not throughout the entire plant.

POWER AND HEAT DISTRIBUTION IN CEMENT MILLS

By L. L. Griffiths, Cement, Dallas Co., Tex.

Member of the Society

This paper considers the methods employed in cement mills for converting the dormant thermal power of fuel into active and productive mechanical motion. It has been the good fortune of the writer to have been in direct charge of several manufacturing plants and data are given with reference to five cement plants which use the thermal power of fuel in different ways.

2 The primary means of developing this thermal power of a fuel is by means of the application of the heat evolved either by total or partial combustion. If by total combustion, the first means commonly employed for the first stage of the power transmission is steam, either saturated or superheated. The prime mover actuated by this steam, whether it be a reciprocating engine or a turbine, is the second step of the power transmission. Then we have the further transmission of this power through means of belted, geared or direct connection of this prime mover to a lineshaft, thence by means of further belts, gears, ropes or chains from the lineshaft to the machine finally operated. Or we have the prime mover actuating a generator from which the power in changed form is transmitted through wires to motors operating the machines either by direct connection or by means of lineshafting, belts, gears, ropes or chains.

3 Where the first stage is the partial combustion of the fuel resulting in the production of an explosive gas, the prime mover then is an internal-combustion engine connected similarly to that described above.

4 In considering the several plants as set forth in Table 1, a brief description is given both of the power installation and the mill

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arrangement, since there is a considerable difference of opinion as to which form of power consumption is the most economical type for crushing, grinding and pulverizing machinery.

5 The item of fuel herein considered as the source of power, is roughly 30 per cent of the manufacturing cost of a barrel of cement and each barrel of cement manufactured represents the conversion of from 2,000,000 to 3,000,000 B.t.u. Of this total amount, 25 per cent is used in the generation of power in the actual mechanical operation of the machinery of the plant, so that it may readily be seen that the means of converting and transmitting this power is worthy of study and consideration.

PLANT No. 1 A 1000-BBL. PLANT NOMINAL CAPACITY

6 When operating 100 per cent of the machinery 100 per cent of the time the daily output of plant No. 1 would be 1000 bbl. of Portland cement. Briefly, its general arrangement is as follows: Stone from the quarry in man-size pieces is crushed in a gyratory crusher, dried in a rotary drier, further reduced in rolls and finished pulverized in Fuller mills. The raw material is burned in rotary kilns, and the cement clinker prepared for pulverizing by passing through toothed crushers and pulverized in 30-in. Griffin mills.

7 The boiler equipment of the power plant consists of three horizontal tubular boilers of 75 h.p. each, four horizontal tubular boilers of 100 h.p. each and one B. & W. water tubular boiler of 340 h.p. The ash-pits of all the boilers are equipped with McClave steam blowers with steam pressure at 100 lb. They are using West Virginia bituminous slack or run of mine, but its use is uneconomical because the grates are set for hard coal. About 60 per cent of the raw end of this plant is driven by an 18 in. by 40 in. Wright noncondensing engine and the balance or 40 per cent of the raw end, and 100 per cent of the finishing end, is driven by a 20 in. and 34 in. by 42 in. tandem compound Corliss engine operating at 100 r. p. m. in connection with a jet condenser and cooling-tower installation. The kiln room is operated by one 11 in. by 11 in. Buckeye noncondensing 150-r.p.m. engine. With this power installation the plant turns out a barrel of cement for 0.839 h.p.

PLANT No. 2 A 1200-BBL. PLANT NOMINAL CAPACITY

8 Plant No. 2 of 1200-bbl. nominal capacity, operates at an output better than 100 per cent because of the excellence of the operating force. The general arrangement is as follows: Stone from the

quarry is crushed in gyratory crushers of the same make and size as in plant No. 1, dried in a rotary drier, also of the same make and size as in plant No. 1, but the material is now ground in ball mills and is finished pulverized in tubemills, then burned in kilns of the same size as those of plant No. 1. The cement is prepared for pulverizing and is pulverized as in plant No. 1.

9 The boiler equipment of the power plant consists of eight double-drum elephant boilers each of 150 h.p. capacity. The furnaces are equipped with balanced-draft burning Buckwheat anthracite coal. The raw end of this plant is driven by one 20 in. and 36 in. by 42 in. cross-compound condensing Corliss engine operating at 87 r.p.m. The finishing end is driven by a duplicate of this engine, and the kiln room is operated by one 11 in. by 18 in. Buckeye 150-r.p.m. noncondensing engine. The coal house, the handling, drying, crushing and pulverizing coal for kiln fuel is operated by one 11 in. by 10 in. vertical Westinghouse 230-r.p.m. steam engine, and one 20 in. by 16 in. Westinghouse 250-r.p.m. engine. This plant produces a barrel of cement on 0.835 i.h.p.

PLANT No. 3 A 2000-BBL. PLANT NOMINAL CAPACITY

10 Plant No. 3 is a more recently constructed plant than either No. 1 or No. 2 and is laid out in a somewhat better manner. This fact together with a more efficient working force, results in an output better than the rated output of 100 per cent. The crushing, grinding and pulverizing machinery of the raw ends, kilns and auxiliaries of the burning department, and crushers and pulverizers of the finishing end, were the same as in plant No. 2, a greater number of the same size units being used for the increased capacity.

11 The boiler equipment of the power plant consists of seven 350-h.p. B. & W. boilers fired by Westinghouse stokers using anthracite pea coal, both coal and ashes being automatically handled by conveyors and elevators. The boilers are also equipped with superheaters and the raw end is operated by one 20 in. and 40 in. by 54 in. cross-compound Corliss condensing engine of 74 r.p.m. The finishing end is operated by a duplicate of this engine, and the kiln room by one 16 in. and 28 in. by 42 in. tandem compound Corliss condensing engine at 85 r.p.m. The coal house is operated by one 12 in. and 24 in. by 42 in. tandem compound Corliss condensing engine of 80 r.p.m. This plant produces a barrel of cement on 0.777 i.h.p. The prime movers in every instance are belted to a main

lineshaft, the individual machines being in turn driven from this lineshaft by belt, chain, rope or gear drives.

12 These three plants are known in the cement business as direct-driven plants: that is, in such plants the prime mover is belted to a lineshaft and the individual machines are in turn driven by belts, gears, chains, etc., from this lineshaft. Plants Nos. 4 and 5 are known as electrically-driven plants.

PLANT No. 4 A 2000-BBL. PLANT NOMINAL CAPACITY

13 Plant No. 4 with a nominal capacity of 2000 bbl., although a comparatively new plant, has never been operated at better than 60 per cent of its nominal rating, due to a very poor arrangement of mixing, conveying and pulverizing machinery. On account of the load condition, however, the electrical efficiency is high in that the motors are operating at from 100 to 125 per cent full load: and the maximum efficiency of the induction motor is at about 120 per cent rated load.

14 The general arrangement of this plant is as follows: Stone in man-size pieces is reduced by passing it through two gyratory crushers; the shale is reduced by passage through toothed rolls. It is dried in a rotary drier, mixed with limestone and further reduced with it in a Williams mill. The material is then passed through two rotary mix driers to 30-in. Griffin mills used as preliminaries to tube-mills, in which the raw material is finished. This is burned in kilns of the same size as those in the No. 2 and No. 3 plants. The clinker is prepared by passing through a toothed crusher and rolls, and pulverized in 30-in. Griffin mills.

15 The boiler equipment of the power plant consists of two 250-h.p. Cahall vertical boilers, four 250-h.p. O'Brien–Heine boilers, and one 375-h.p. O'Brien-Heine boiler. The fuel used is Southern Indiana bituminous coal and with the exception of the Cahall boilers, the setting and grates are for hard coal. The furnace efficiency is therefore low. The prime movers in this plant are two vertical Curtis turbines, one direct connected to a 1000-k.w. three-phase, 25-cycle, 440-volt alternator, and the other to an 800-k.w. alternator. Each individual machine throughout the plant is driven by an individual motor of proper size by a belt from the motor pulley to a shaft and from the shaft to the machine either by gears, belt, or chain drive. This plant consumed 1.26 h. p. per bbl. of cement produced.

PLANT No. 5 A 2500-BBL. PLANT NOMINAL CAPACITY

16 Plant No. 5 comes under the same heading as plant No. 4, but is unique in that it is the only one which starts with partial combustion of the fuel, and discarding steam as a means of power transmission between the fuel bed and the prime mover, uses the gas direct from the fuel in an internal-combustion or gas engine. Due to the difficulty of mixing and combining the raw materials of the section in which the plant is located it is operating at about only 80 per cent of its capacity at the output figures given. The basis of comparison therefore, for the grinding, pulverizing and burning machinery, which is operating on cement rock in the Lehigh Valley, is not a fair one.

17 The stone is loaded with a steam shovel, crushed in a gyratory crusher, further reduced in a Williams mill, and dried in rotary driers. The shale or clay is loaded with a steam shovel, run through a dry pan mill, dried, and meets the stone at the weigh bin where the mixture is proportioned. It then passes through a rotary mixer to ball mills and is finished in tubemills, burned in rotary kilns, and the cement clinker then crushed in ball mills and finished in tubemills.

18 Electrically, the conditions are practically the same as those described for plant No. 4.

19 The power plant consists of six up-draft producers in place of the usual steam boilers, the generating gas operating three 34 in. by 48 in. horizontal tandem gas engines driving three 750-k.w. three-phase, 25-cycle, 440-volt alternators.

20 It may appear that this paper emphasizes the relative efficiencies of different raw materials, types of grinding machinery and engineering arrangements. The presence of these as variables is admitted, especially when the plants cited are in different localities, but fortunately we have exactly the same types of machinery and in most cases the same size and make in the comparisons given, if not throughout the entire plant at least throughout entire departments which represent the several stages in the manufacture of cement from the raw materials.

21 In explanation of the lettering of the different departments in Table 1 the quarry is considered as A; preliminary crushing, secondary breaking down and storing of the raw materials as B_1; the drying, grinding and pulverizing of the raw material as B_2; sub-divisions, B_1 and B_2 as the raw end B; burning the raw material to cement clinker and cooling it as department C; crushing, grinding and pulverizing the cement clinker as department D, — D_1 being the preliminary crushing and grinding, and D_2 the finishing or pulverizing.

22 Comparing the figures in Tables 1 and 2 in connection with the brief description of the plants, it is seen that a direct-driven plant shows a power economy greater than an electrically driven plant.

23 Plants Nos. 2, 3 and 5 are comparable in departments B_1 and B_2 with but small opportunity of error in that the size, type and make of the granulating and pulverizing machinery is identical. It will be noted that a barrel of finished raw material at the kiln bins department B, consumes as follows:

	I. H. P.	
	Total	Per Bbl.
Plant No. 1	387	0.403
Plant No. 2	416	0.341
Plant No. 3	602	0.276
Plant No. 4	736	0.626
Plant No. 5	860	0.478

24 Plants Nos. 3 and 4 have twice the number of kilns, feeders for both pulverized coal and raw material, low-pressure air systems, elevators and auxiliaries that plant No. 2 has. Plant No. 5 has the same number of kilns, etc., as plant No. 2, but the kilns have twice the area and length and the auxiliaries are twice as large. We have as a comparison, however:

	I. H. P.	
	Total	Per Bbl.
Plant No. 1	38	0.0396
Plant No. 2	37	0.0303
Plant No. 3	159	0.073
Plant No. 4	86	0.0732
Plant No. 5	170	0.0945

25 In the clinker-grinding and finishing departments D we find a greater difference in the machinery used, that is: when comparing plants Nos. 2, 3 and 5, but the department D of plant No. 4 is comparable with that of plants No. 2 and No. 3 with reference to the grinding machinery used, and we have:

	I. H. P.	
	Total	Per Bbl.
Plant No. 1	300	0.312
Plant No. 2	476	0.390
Plant No. 3	750	0.341
Plant No. 4	531	0.452
Plant No. 5	962	0.534

From the above it will be noted that in practically every instance the direct-driven plant is more economical in power consumption, than the electrically driven plant.

26 In considering this subject it has appeared to me that the pounds of coal used per indicated horsepower do not show the true condition, so the equivalents in British thermal units are given in Table 2.

TABLE 1 DATA UPON THE POWER DISTRIBUTION IN FIVE CEMENT PLANTS

Plant No. 1	1	2	3	4	5
Nominal Capacity, Bbl	1000	1200	2000	2000	2500
Actual Capacity, Bbl	960	1220	2180	1176	1800
Indicated Horse Power					
Gross Developed	805	1020	1694	1480	2430
Cement per Bbl	0.839	0.835	0.777	1.26	1.35
Hours, per Bbl	20.15	20.04	18.65	30.75	32.4
Coal Cost, per Ton	$2.76	$2.12	$2.45	$1.25	$1.50
Cost Coal, Cents per H.p-hr	0.00655	0.00325	.00411	0.00119	0.0019
Lb. per H.p.	5.32	3.44	3.8	6.7	2.87
Proportion to Departments					
B_1, H.p.	.....	.....	.....	189	136
%	.....	.....	.....	12.7	5.6
B_2, H,p	.....	.....	.....	547	724
%	.....	.....	.....	36.8	29.8
B, H.p.	387	416	602	736	860
%	48	40.75	35.5	49.5	35.4
C, H.p.	38	37	159	86	170
%	4.5	3.5	9.5	5.8	7.0
D_1, H.p.	.....	.....	.....	.....	.....
%	.....	.....	.....	.....	.....
D_2, H.p.	.....	.....	.....	.....	.....
%	.....	.....	.....	.....	.....
D, H.p.	300	476	750	531	962
%	38	46.75	44.5	35.7	39.6
Coal, Gr.	80	90	183	132	438
%	9.5	9.0	10.75	8.86	18

TABLE 2 HEAT UNITS PER I. H. P. PER BARREL CEMENT

Plant No.	Coal, Lb. per I.H.p.-Hr.	B. t. u. per I.H.p.-Hr.	Power Coal, Lb. per Bbl. Cement	B. t. u. per Bbl. Cement
1	5.32	71,022	107.19	1,430,960
2	3.44	40,560	68.94	792,782
3	3.80	45,600	70.87	850,440
4	6.7	82,745	200.03	2,470,308
5	2.87	21,094	92.99	683,462

27 From Table 2 it appears that the power plant No. 5 using the most direct method of transmitting the thermal power of the fuel to the prime mover, i.e., by means of the gas generated by partial combustion of the fuel in a producer, shows the lowest B.t.u. consumption and highest thermal efficiency, but on account of the losses inherent in the balance of the power transmission system, uses more i.h.p. per bbl. of cement produced than do plants Nos. 1, 2, 3 and 4. The same is true of plant No. 4 as compared with plants Nos. 1, 2 and 3, from which it appears to me that in addition to all of the losses inherent in a direct-driven plant, the electrically driven plant has in addition those decreased efficiencies representing losses in the conversion of mechanical power to electrical power and back from electrical power to mechanical.

28 We have for instance in plants Nos. 1, 2 and 3 the fuel fired under boilers, generating steam which in turn is used in the engines giving motion and power to the lineshaft. Through the aid of a belt this power is then transmitted to the several machines by means of belts, gears, chains, ropes, etc. In this arrangement we have the losses shown in column 1 below.

29 In plant No. 4 the fuel is fired under boilers, and steam is used in the turbine to generate electrical current in the alternators, the current produces motion and power in the motors which is transmitted to the machines, through a belt to a counter-shaft, and thence by belt, gearing, chain or rope to the machine, and the losses are as shown in column 2 below.

30 In plant No. 5 the fuel is fired into a producer which supplies gas to an engine operating an alternator generating current from which point the cycle is the same as in plant No. 4, and the losses are as shown in column 3 below.

Plant Numbers		
1, 2 and 3	4.	5.
Furnace	Furnace	Producer
Boiler	Boiler	Engine (gas)
Engine	Engine (turbine)	Generator
Belting	Generator	Line
Lineshaft	Line (circuits)	Motor
Lineshaft	Motor	Belt
Belting	Belt	Lineshaft
	Lineshaft	Belt
	Belt	

31 The above are all comparable on a monetary basis, but time and space will not permit going into this. It is appreciated that given a water-power proposition, that the proper installation is a hydro-electric one, but it is believed that the most economical cement plants of the future, that is, from a power consumption standpoint, will be developed along the lines of a producer as the first step in the cycle of power conversion and transmission; then an internal-combustion engine operating the main departments direct connected to the lineshaft, and the waste heat from these engines utilized in an exhaust or low-pressure steam turbine operating direct-currrent generators, which current so generated will be used for lighting and the operation of isolated and remote machines.

QUANTITY MANUFACTURE OF SMALL DEVICES

By F. P. Cox

ABSTRACT OF PAPER

This paper deals with the production of small but not particularly complicated devices. It assumes that the apparatus has been properly designed for economical manufacture, and discusses the organization of the shop.

The author considers it essential that change of design, except at stated periods, should be avoided; that the responsibilities of the different assistants should be sharply defined, and should not overlap; that stock handling is of the greatest importance in order to avoid interference with the labor cost, and that the chief function of an organization is to assist the workman to perform a maximum of work with a minimum of effort. Recognizing and fully believing in scientific management, he contends that an organization should be sufficiently flexible that ability in whatever form it may be found may be used to advantage, and in no case should the man be sacrificed to the system.

QUANTITY MANUFACTURE OF SMALL DEVICES

By F. P. Cox,[1] West Lynn, Mass.

Non-Member

The economical manufacture of small devices in large quantities is chiefly characterized by the attention which must be given to details. The cost of material is in general proportionally small, and in any case more or less fixed by the design; but the labor item is large and requires constant and careful scrutiny. Unlike other lines of manufacture, each operation is repeated over and over again and, therefore, warrants a considerable expenditure of time and money to determine exactly the best manner in which to perform it. It is desirable to know just how economically it can be performed even though temporary conditions prevent an immediate realization of possible results.

2 This leads to scientific rate setting, and the advantages of such an experimental manufacturing department are too well known to require comment. It means automatic machinery for many operations, but not for all; it means suitable provision for stock handling, inspection, supervision, etc. Each of these subjects, if covered completely, would require an individual paper. In addition, it requires organization to provide for the proper correlation of these various elements and to insure their harmonious operation.

3 Many plans of organization along the same general lines are possible. The general lines are subject to variations at times, but they are all centered around the same principal object, the labor item. No manager will ever be able fully to realize his ideal system, and perhaps the chief reason will be found in the limitations of his assistants. An organization which has been in operation for any length

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of time will have developed a certain number of individualities which must be reckoned with in any contemplated change. It would be folly to dispense with a man of proved value because he doesn't happen to fit exactly in an ideal plan of organization. It is always possible to modify the system to avoid such a sacrifice and without any material departure from the original scheme.

4 An equivalent system can be devised with comparatively little difficulty, but the equivalent of a tried man is hard to find. Of course this does not mean that a weak man should be retained, nor that one not in sympathy with the plan of organization should be permitted to take part in its administration. Neither does it mean that any effort should be spared to find and employ a competent man to fill an important part in the general scheme. It does mean, however, that a man whose known limitations prevent him from filling all the duties of a certain position should have those duties so modified that he will not be prevented from filling those for which he has been found particularly adapted; and that one who has shown particular ability in handling two or more lines, not originally intended to be combined, may still exercise this talent by a reasonable modification of the system.

5 The organization here outlined probably differs very little from similar organizations intended to cover the same field.

Manager
- *a* Superintendent
  - (1) Production clerk
  - (2) Stock clerk
  - (3) Material list department
  - (4) Rate setting department
  - (5) Automatic tool department
  - (6) Shop accountants
  - (7) General foreman
  - (8) Inspectors
  - (9) Tool department
- *b* Engineer
  - (1) Designer
  - (2) Draftsmen
  - (3) Model room
- *c* Cost department

6 The strength of this organization lies in the fact that each feature of manufacture is under control of a man particularly qualified

to handle it in the best possible manner, and that his responsibility is definitely fixed and limited to the proper performance of his own part of the work. There is no overlapping of responsibility and no possibility of misunderstanding. Any failure to produce a part is at once traced to the responsible party. For example, if a leading-hand finds that he is not receiving his parts in adequate numbers and is, consequently, handicapped, he at once reports to the stock clerk who has failed in his duty. The stock clerk realizes that he has failed. The mere absence of parts is convincing evidence of the fact, and he must correct the shortage before it becomes a limiting feature or report his inability to do so to the superintendent.

7 In this way, the superintendent is constantly advised of matters which are liable to interfere with his business, and is able to apply corrective measures before the situation is serious.

8 When everything is moving properly, if such condition should ever exist, the work of the various departments becomes routine, but the moment any trouble appears in the distance, an alarm is sounded. If trivial in character, it is corrected without any great disturbance, but if important, it comes at once to the highest authority and the whole strength of the organization is applied promptly to correct it.

9 The functions of the different departments are, in general, sufficiently described by their names. It may be necessary to add that all material is ordered by the material list department, but the following of the stock into and through the shop rests with the stock clerks, and that while the inspectors come under the superintendent, the limits of inspection are set by the engineers.

10 The workman is the principal subject of study and every effort must be made to shorten the time and lessen the effort required to perform the operation for which he is engaged. It may mean automatic tools, increased facilities, improved methods, or the splitting of the operation so that a portion of it may be done by a less skilled operator, who is competent to do this portion in a satisfactory manner.

11 Always inspection is involved in order that no time may be spent on a piece which is already defective and will ultimately be rejected or require special fitting, which is necessarily expensive. The proper time to reject a piece or to correct it is immediately after the false operation has been completed.

12 In order that a workman may perform a maximum of work with a minimum of effort, it is necessary that the piece shall come to him in ample quantity and at a constant rate; that previous operations shall have been properly performed, and that the piece shall be

promptly inspected and removed. His whole thought and effort should be given to performing his own operation satisfactorily. One portion of this desired result may be obtained by a large stock of parts, but this means unnecessarily large inventory, and should be rejected. It is just as necessary that parts should not wait for the workman as it is that the workman should not wait for parts.

13 Regular and frequent meetings are held by the superintendent and his assistants, so that each may be familiar in a general way with conditions as a whole, but such meetings are not to be construed as lessening the responsibility of the different departments. These meetings require but little time if everything is going smoothly, and justify the time taken if there is any prospect of trouble.

14 Similar meetings are held weekly by the manager, engineer and superintendent, and are more or less generally attended by principal assistants. Change of design or method are freely discussed at these meetings, and they serve as a clearing house for all matters of interest which have come up during the week and which are not of sufficient importance to require instant attention.

15 Changes of design, unless to correct defects in the apparatus are docketed and not acted on singly as they arise. Low costs cannot be obtained where the design is continually changing, and minor changes should be held for an apparatus meeting. Such meetings are held at regular intervals of from three to six months. When a line of apparatus has but recently been placed in the shop, the interval is shorter than when it has become more firmly established and original troubles eradicated.

16 Apparatus meetings are attended by the manager, engineer, cost department and superintendent, with their assistants who have the actual handling of the apparatus. The device is placed on the table and gradually dissected, each part being fully discussed as it is taken off, and the presence of the leading hand is considered essential during the discussion of the particular part or operation with which he is concerned. The leading-hand, or gang boss, comes under the general foreman. He has direct charge of a rather small number of operators, and often a portion of his time is given to productive labor. More than anyone else he appreciates inconveniences and difficulties which arise in producing his particular part, and any organization which fails to profit by such knowledge is fundamentally defective. Introduction of automatic tools, change of methods or of design, and quality of product are thoroughly gone into and after this meeting all changes decided upon are authorized at one time after which none are made until the next change period.

GENERAL NOTES

AMERICAN INSTITUTE OF MINING ENGINEERS

A meeting of the American Institute of Mining Engineers will be held in San Francisco, Cal., October 10 to 16, 1911. There will be the usual sessions for the reading and discussion of technical and professional papers, and the local committee is considering a number of excursions in and about the city, including the Oil Fields, Gold Dredges, Mt. Tamalpais, the Lick Observatory, Mt. Hamilton, and possibly longer trips to Grass Valley, Nevada City, and the Mother Lode district. As an added attraction, it is proposed to organize a preliminary excursion by a special train *de luxe* from Chicago to San Francisco, and return to Chicago after the conclusion of the meeting. On the outward trip a day or two each will be spent at the Grand Canyon of Colorado in Arizona, Los Angeles, Santa Barbara and Del Monte.

In reply to the preliminary notice sent out January 24, 1911, more than 75 members and guests have already announced their intention to attend the excursion of the institute to Japan. The number of the party is limited to 100, and in order to facilitate the completion of the preliminary arrangements, it is urged that all who intend to make the trip signify their intentions at once.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

The annual meeting of the American Institute of Electrical Engineers was held in the Engineering Societies Building, New York, May 16, 1911. The main feature of the program for the evening was the ceremonies in connection with the presentation of the Edison medal to Frank J. Sprague. A number of addresses were made indicating the result of Mr. Sprague's work along the lines of electricity in the navy. Among the speakers and subjects were: The Development of the Electric Railway, W. B. Potter, Mem. Am. Soc. M. E. Social Results of the Introduction of the Electric Railway, F. H. Giddings; The Relation of Governmental Control to the Development of Electric Railways and the Electrification of Steam Lines, G. F. Swain, Mem. Am. Soc. M. E. also an address on The Results of the Use of Electricity in the Navy. Calvin W. Rice, Secretary of the Society, attended the meeting as a guest of honor.

The annual convention of the American Institute of Electrical Engineers will be held in Chicago, Ill., June 26 to 30, 1911, with headquarters at the New Hotel Sherman. The following papers will be presented: Economical Design of Direct-Current Magnets, R. Wikander Catenary Span Calculations, W. L. R. Robertson; Currents in Inductors of Induction Motors, H. Wiecshel; Multiplex Telephony and Telegraphy by Means of Electric Waves Guided by Wires, G. O. Squier; Electrolysis in Reinforced Concrete, C. E. Magnusson, G. H. Smith, Mem. Am. Soc. M. E.; Induction Motor Design, T. Hoock; The High

Efficiency Suspension Insulators, A. O. Austin, Mem. Am. Soc. M. E.; The Electric Strength of Air II, J. B. Whitehead; Electrification Analyzed, and Its Application to Trunk Line Roads, W. S. Murray; Telegraph Transmission, F. F. Fowle; The Cost of Transformer Losses, R. W. Atkinson, C. E. Stone; The Cost of Railway Electrification, B. R. Wood; Induction Motor for Single-Phase Traction, E. F. W. Alexanderson; Properties of Iron at 200,000 Cyles, E. W. F. Alexanderson; Electric Magnetic Storage Batteries, B. Ford; The Characteristics of Isolated Plants, P. R. Moses; Elevator Control, T. E. Barnum: and Limits to the Use of Resistance of Materials.

INTERNATIONAL RAILWAY FUEL ASSOCIATION

The annual convention of the International Railway Fuel Association was held at Chattanooga, Tenn., May 15–18, 1911, with headquarters at the Hotel Patten. The following papers were presented: Fuel Investigations under the Bureau of Mines, J. A. Holmes, Mem.Am.Soc.M.E.; How to Organize a Railway Fuel Department and Its Relation to other Departments, T. D. Smith; The Testing of Locomotive Fuel, F. O. Bunnell; Standard Locomotive Fuel Performance Sheet, F. C. Pickard; The Railway Fuel Problem in Relation to Railway Operation, R. Emerson; Petroleum, Its Origin, Production and Use as Locomotive Fuel, E. McAuliffe.

FOUNDRYMEN'S ASSOCIATION

The American Foundrymen's Association, American Brass Founders' Association and the Associated Foundry Foremen held their annual conventions in Pittsburg, Pa., May 23 to 26, 1911. The papers read before the different sessions were: Production Cost, Economic Foundry Insurance, Uniform Contracts, Unloading Methods, Use of Borings in Cupolas, Effect of Alloys in Cast Iron, Permanent Molds, Vanadium in Non-Ferrous Alloys, Determination of Nickel Bronzes, Pouring High Grade Bronzes, Rotary Blowers, Foundry Construction, Heating and Lighting Systems, Pattern Making, Molding Machines, Acid and Basic Open-Hearth Processes, Electric and Converter Furnaces for Steel Castings, Effect of Vanadium and Titanium on Steel, Corrosion of Brass Foundry Products, Pyrometer and the Aluminum Foundry, Non-Ferrous Foundry Economies, Equilibrium Diagrams, Molding Sand, Use of Alloys, Shot in Castings.

IRON AND STEEL INSTITUTE

The annual meeting of the Iron and Steel Institute was held at the Institution of Civil Engineers, London, England, May 11 and 12, 1911. At the opening session the Bessemer Gold Medal for 1911 was presented to Prof. Henry Le Chatelier and the Andrew Carnegie Gold Medal for 1910 to Felix Robin. The awards of the Andrew Carnegie Research Scholarships for 1911 were also announced. Among the papers presented and discussed were the following: On Temperature Influences on Carbon and Iron, E. Adamson; On the Chemical and Mechanical Relations of Iron, Chromium and Carbon, J. O. Arnold, A. A. Read; On the Growth of Cast Irons after Repeated Heatings, H. C. H. Carpenter; On the

Relation of Impurities to the Corrosion of Iron, J. W. Cobb; On Magnetic Properties of some Nickel Steels with some notes on the Structures of Meteoric Iron, E. C. Glauert, S. Hilpert; Notes on a Process for the Dessication of Air by Calcium Chloride, F. A. Baubinè, E. V. Roy; On the Volumetric Estimation of Sulphur in Iron and Steel, T. G. Elliot; On the Action of Aqueous Solutions of single and mixed Electrolytes on Iron, J. N. Friend, J. H. Brown; On Iron-Silicon-Carbon Alloys, W. Gontermann; On the Influence of Vanadium upon Cast Iron, W. H. Hatfield; On the Organic Origin of the Sedimentary Ores of Iron, W. H. Herdsman; On Some Studies on Welds, E. F. Law, W. H. Merrett, W. P. Digby; On the Corrosion of Steel, P. Longmuir; On the Influence of 2 Per Cent of Vanadium on Steels of Varying Carbon Content, A. McWilliam, E. J. Barnes; On Some Properties of Heat-Treated 3 Per Cent Nickel Steels, A. McWilliam, E. J. Barnes; On Mechanicalising Analysis as an Aid to Accuracy and Speed for Commercial Purposes, C. H. Ridsdale, N. D. Ridsdale; On Welding up of Blowholes and Cavities in Steel Ingots, J. E. Stead.

AIR BRAKE ASSOCIATION

The annual convention of the Air Brake Association was held in Chicago, Ill., May 23–26, 1911, the headquarters being at the Auditorium Hotel. Papers presented were as follows: Air Brake Instruction, Rating, T. Clegg, Geo. A. Wyman, H. H. Burns, H. A. Wahlert, T. F. Lyons; Brake Cylinders and Connections, H. A. Wahlert; Adequate Braking Power for Freight Cars, J. P. Kelly; Cost of Maintenance of Locomotive Brakes, W. P. Huntley; Running Triple Valves without Lubricants, L. Leonard; Fibre Stresses in Brake Gear Parts, G. O. Hammond; "P. C." Equipment, W. V. Turner; Steel Pipe vs. Iron Pipe, J. R. Alexander; Recommended Practice, S. G. Down, G. R. Parker, H. A. Wahlert, N. A. Campbell, J. R. Alexander; Friction of New and Worn Brake Shoes on New and Worn Cast Wheels, A. S. Williamson; Breaking-in-two of Trains, S. H. Draper, P. J. Langan.

NATIONAL ELECTRIC LIGHT ASSOCIATION

Among the papers read at the annual convention of the National Electric Light Association held at New York, May 30 to June 2, 1911, were the following: Master and Men, Paul Lupke; Electrical Exhibitions, L. A. Ferguson; Valuation of Properties as Related to Rated, W. F. Wells; Reasons for Variations of Rates under Varying Conditions of Operation, N. T. Wilcox; The Standardization of Electrical Selling, Douglass Burnett; Economies in Operation Possible through Time Study, L. B. Webster, Mem.Am.Soc.M.E.; The Ventilation of Turbo-Generators, R. B. Williamson; Progress and Development in Self-Cooled Transformers, H. O. Troy; Grounding Low-Tension Circuits, P. M. Lincoln, Mem.Am.Soc.M.E.; Recent Improvements in Single-Phase Motors, W. A. Layman; Relation of Motor Load to Central Station Equipment, F. D. Newbury; Utilization of Central Station for Supply of Electricity to Operate Railroads, Fred. Darlington; A New Method of Reducing the Investment in Central Station Boiler Plants, H. A. Wagner; Determining Cost of Production in Steam Properties under Varying Conditions, G. H. Walbridge.

Reports were also presented as follows: Overhead Construction, Library, Rate Research, Section Organization, Underground Construction, Meters, Prime Movers, Electrical Apparatus, Grounding of Secondaries, Governmental Control of Water Power and Lightning Protection, Electricity in Rural Districts, Improved Standards of Industrial Lighting.

NATIONAL ASSOCIATION OF MANUFACTURERS

The annual convention of the National Association of Manufacturers was held at the Waldorf Astoria, New York, May 15 to 17, 1911. Among the labor problems considered were the prevention of accidents and the question of industrial relief. The results of the investigations made in Europe by F. C. Schwedtman and J. A. Emery were presented before the convention. A special feature was made of banking and currency, and the attitude of our manufacturers towards the plans recently proposed of reforming our banking and currency systems were discussed. Other questions of economic importance, such as immigration, industrial education, and a reform of our patent laws, were also discussed.

OHIO SOCIETY OF MECHANICAL ELECTRICAL AND STEAM ENGINEERS

The semi-annual meeting of the Ohio Society of Mechanical Electrical and Steam Engineers was held at Youngstown, O., May 18 and 19, 1911. Interesting excursions were made to the works of the Youngstown Sheet and Tube Company, to the Ohio Works of the United States Steel Corporation, to the General Fire-Proofing Company, the Trussed Concrete Steel Company, the Republic Rubber Company and other works. Among the papers read were: Flue Gas Analysis, J. W. Hays; The Engineering Features of the Columbus Garbage Reduction Plant, I. F. Osborn: Industrial Motor Control, D. Martignone: General Comments Concerning Hydro-Electric Development in Central West, P. M. Lincoln, Mem. Am. Soc. M. E.; Centrifugal Blowers, Dr. Lowestein.

PERSONALS

Through an error, the following statement appeared in the May issue of The Journal: L. B. Alexander was appointed general sales manager of the Bosch Magneto Co. This should read, assistant general sales manager.

T. S. Bailey, formerly chief engineer of the Electric Boat Co., Quincy, Mass., has become associated with The New London Ship and Engine Co., New London, Conn.

Orville G. Bennet, formerly associated with the Okonite Co., New York, has accepted a position with the General Motors Co., Detroit, Mich.

Chas. E. Burgoon has resigned his position as chief engineer of the U. S. Court House and Post-Office Building, Chicago, Ill. and has become associated with H. W. Matthews. They have formed the Burgoon-Matthews Electric Co., Atlanta, Ga.

Harry M. Chamberlain has become connected with the Macker-Tyler Co., Worcester, Mass. He was recently with the N. Y. C. & H. R. R. R., West Springfield, Mass.

Herbert A. Croxton, formerly president and treasurer of the Massillon Iron & Steel Co., Massillon, O., has been appointed president and general manager of the Consolidated Motor Car Co., Cleveland, O.

T. F. Dreyfus has become connected with the Baltimore & Ohio R. R. Co. as motive power inspector, with headquarters in Wheeling, W. Va.

Harry K. English has been appointed secretary of the Ottumwa Iron Works, Ottumwa, Ia. He was formerly associated with the General Electric Co., Chicago, Ill.

D. C. Fenner has left the employ of the Knox Automobile Co., Springfield, Mass., to accept the position of sales manager of the Alden Sampson Manufacturing Co., with offices in New York.

C. E. Hardy has become identified with the Westinghouse Electric & Manufacturing Co., San Francisco, Cal. as industrial engineer. Mr. Hardy was formerly assistant shop superintendent of the manufacturing department of the U. S. Navy Yard, Mare Island, Cal.

Paul L. Joslyn, recently associated with the Nordberg Manufacturing Co., Milwaukee, Wis., has accepted a position with the Union Iron Works, San Francisco, Cal.

John S. Nicholl, formerly with the N. Y. Edison Co. is now associated with Walter B. Snow, Publicity Engineer, Boston, Mass.

Alfred Noble has been elected an honorary member of the Institution of Civil Engineers, being the only American engineer now possessing this distinction.

D. T. Randall has been transferred from the Boston office of Arthur D. Little, Inc., to take the position of resident engineer to organize and direct an engineering department for the purpose of testing the material and the products used by the General Motors Co., Detroit, Mich.

John J. Swan has become identified with the Chicago Pneumatic Tool Co., New York. He was until recently connected with the Keller Manufacturing Co., Philadelphia, Pa.

L. R. Valentine has recently entered the service of Dodge, Day & Zimmermann, Philadelphia, Pa. Mr. Valentine was formerly identified with the Charles Warner Co., Devault, Pa.

Ralph D. Van Valkenburgh has been appointed district sales manager of the Colonial Steel Co., Pittsburg, Pa., in charge of their Chicago office and warehouse. He was recently district manager for the Taylor Iron & Steel Co., Scranton, Pa.

C. von Goeben, formerly located in New York, has assumed the duties of manager of the works of the Payne & Joubert Machine and Foundry Co., Birmingham, Ala.

L. L. Willard has accepted the position of chief mechanical engineer of the Allis-Chalmers Co., Uniontown, Pa.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary, Am.Soc.M.E.

Aerial or Wire Rope-Ways, their Construction and Management. By A. J. Wallis-Tayler. *London, Crosby Lockwood & Son, 1911.*

This is a revision of the author's Aerial or Wire-Rope Tramways. Much new matter is added on such subjects as coaling vessels at sea. The work is illustrated and has a good index.

Twentieth Century Sheet Metal Worker. By H. E. Osborne. *Chicago, American Artisan, 1910.*

Distribution of Gas. By Walter Hole. ed. 2. *London, J. Allan & Co., 1909.*

This is the first and only work in any language that deals exclusively with the important subject of distribution of gas. It is reprinted with additions from articles published in the Gas World. The author is superintendent of the Leeds, England, gas mains and distribution department, and has had 30 years' experience in gas distribution. A chapter on fusion and electrolysis has been added to this edition.

Electric Wiring Diagrams. By W. P. Maycock. *London, Whittaker & Co., 1900.* Gift of the Macmillan Co.

This is an abbreviation of the same author's larger work Electric Wiring, Fittings, Switches and Lamps. It is intended as a reference book of connections for all those who are concerned with or engaged in electric wiring. In one small volume of 146 pp. it gives practically all the diagrams in the larger work, but abbreviates the descriptive matter.

Factory Organization and Costs. By J. L. Nicholson. *New York, Kohl Technical Publishing Co., 1909.*

Gas Engine Manual. By W. A. Tookey. *London, Percival Marshall & Co., 1908.*

Die Gasmotorentechnik. Vols. 1–5, 6, nos. 1–9. *Berlin, 1901-1906.*

Handbook for Heating and Ventilating Engineers. By J. D. Hoffman. *Lafayette, Ind., 1910.*

Junior Engineering Society. Record of Transactions. Vols. 1, 1884–1891; Vol. 4, 1893–1894. *London.* Gift of the Junior Institution of Engineers.

New York Central and Hudson River Railroad Company. 42d Annual Report, 1910. *New York, 1910.* Gift of the company.

New York City Board of Water Supply. 3d Annual Report, 1908. *New York, 1908.* Gift of the board.

NEW YORK STATE EDUCATION DEPARTMENT. Arbor Day, Forests of New York, 1911. *Albany, 1911.* Gift of the department.

NORTHWESTERN UNIVERSITY. Annual Catalogue, 1910–1911. *Evanston, 1911.* Gift of the university.

PRODUCTION AND CONSUMPTION OF IRON ORE AND PIG IRON, and the Production of steel, in the United Kingdom and the Principal foreign Countries in Recent Years, and the Imports and Exports of Certain Classes of Iron and Steel Manufactures, so far as the Particulars can be Stated. *London, 1910.*

RAILWAY STATISTICS OF THE UNITED STATES OF AMERICA FOR YEAR ENDING JUNE 30, 1910. *Chicago, 1911.* Gift of Slason Thompson.

RIVER AND HARBOR IMPROVEMENTS UNDER THE CORPS OF ENGINEERS U. S. ARMY. By W. H. Bixby. (An address delivered December 8, 1910). Gift of U. S. Army Corps of Engineers.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION. Proceedings, Vol. 18. *Ithaca, 1911.* Gift of the society.

SPRINGFIELD, MASS. WATER COMMISSIONERS. 37th Annual Report, 1910. Gift of the board.

STRAIGHT LINE ENGINEERING DIAGRAMS. By Manifold & Poole. *San Francisco, Technical Publishing Co.*

TECHNICAL DICTIONARY IN SIX LANGUAGES. (Deinhardt-Schlomann Series.) Vol. 9, Machine Tools. *London, 1910.*

U. S. INTERSTATE COMMERCE COMMISSION. Block Signals on the Railroads of the United States. January 1, 1911. *Washington, 1911.*

VEREINS DEUTSCHER INGENIEURE. Zeitschrift, Vols. 6–7, 1862–1863. *Berlin, 1862-1863.*

EXCHANGES

INSTITUTION OF CIVIL ENGINEERS. Minutes of Proceedings. Vol. 183. *London, 1911.*

INDEX OF PAPERS AND SUBJECTS DISCUSSED BY RAILWAY CLUBS FROM MAY 31, 1909 TO MAY 31, 1910. *Society of Railway Clubs.*

JOHN CRERAR LIBRARY. 16th Annual Report, 1910. *Chicago, 1911.*

VEREIN DEUTSCHER EISENHÜTTENLEUTE. MITGLIEDERVERZEICHNIS, 1911. *Dusseldorf, 1911.*

UNITED ENGINEERING SOCIETY

BLACK HILLS, SOUTH DAKOTA. THE RICHEST HUNDRED MILES SQUARE IN THE WORLD. ed. 7. *Chicago & Northwestern Railway, 1909.* Gift of T. E. Cassidy.

TRADES CATALOGUES

AMERICAN KRON SCALE CO., *New York,* Bull. no. 2, automatic springless scales 15 pp.

C. L. BARKER, *Norwalk, Conn.* Catalogue J., Barker motors, 28 pp.

DONEGAN & SWIFT, *New York.* Boilers, stacks and tanks, 56 pp.; Steam engines, 31 pp.

ERIE PUMP & ENGINE WORKS, *Erie, Pa.* Centrifugal pumping machinery, 32 pp.

GRAY MOTOR CO., *Detroit, Mich.* Gray motors for motor boats, 31 pp.

WATSON, LAIDLAW & CO., *Glasgow, Scotland.* "Weston" hydro-extractors, 35 pp.; "Weston" centrifugals and accessories for treatment of sugar, 123 pp.

WILLIAM SELLERS & CO., *Philadelphia, Pa.* Locomotive injectors and boiler attachments, 76 pp.

EMPLOYMENT BULLETIN

The Society has always considered it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both for positions and for men available. Notices are not repeated except upon special request. Copy for notices in this Bulletin should be received before the 12th of the month. The list of men available is made up of members of the Society and these are on file, with the names of other good men not members of the Society, who are capable of filling responsible positions. Information will be sent upon application.

POSITIONS AVAILABLE

097 Assistant to superintendent, concern manufacturing heavy hydraulic tools, centrifugal pumps, heavy machinery and foundry work. The requirements for the position are more in the line of quality of experience, good business ability and capabilities to enforce regulations without creating irritation, than specific engineering qualifications. Location, New Jersey.

098 Representative for leading machine tool concern in middle west, as salesman and specialist. Should have proper knowledge of machine shop methods, able to recommend machines and equipment for increasing output. Technical graduate preferred.

099 Machinery salesman not over 35, reasonably familiar with machinery in general and having some business experience. Would be expected to travel perhaps half of time. Location, New York State.

0100 Chief Draftsman familiar with manufacture of small parts. Location, Massachusetts.

0101 Draftsman qualified to prepare designs for heavy weight electric motor trucks. Location, New York.

MEN AVAILABLE

219 Junior, at present assistant engineer for large concern in Delaware, desires to make a change and locate in or near New York City. Technical education followed by nine years' experience in manufacturing business as draftsman, designer and chief draftsman giving broad training. Would like to correspond with a factory manager needing an assistant who is progressive and familiar with scientific shop methods.

220 Associate, will be open for an engagement June 1. Ten years' experience handling operation of power plant and maintaining shop equipment.

221 Technically trained engineer, experience shop work, machine, pattern, steel, etc.; six years in sales department. Age 34; prefers position in business end or executive position. Several years drafting in conveyor business.

222 Mechanical engineer, at present assistant chief engineer of one of the largest mining and smelting companies in the United States, desires to locate in middle west. Experience covers power plants, engines, mining, milling and smelting machinery in designs and installation, and the supervision of construction of large plants.

223 Stevens graduate, two and one-half years' experience in manufacture and erection of high and low-pressure piping, as erecting foreman and assistant superintendent. Desires similar position.

224 Graduate mechanical engineer, six years' experience in designing and drafting, research and experimental work in steam engineering. At present employed, but desires change with view to advancement.

225 Superintendent or works manager, 20 years' experience in manufacture of machine tools, steam engines, especially turbines and automobiles; open for engagement about May 15. Ten years in charge as general foreman, superintendent and works manager. Only first class proposition will be considered.

226 Member, technical graduate, desires position as sales engineer. Experienced as skilled mechanic, chief draftsman and superintendent of construction of power plant equipment. Four years in New York and one year in Chicago as sales engineer.

227 Mechanical engineer, technical education, six years' experience with blast furnace and gas engine design and construction. Desires a position with blast furnace as superintendent of construction or engineer in charge of design. Age 30.

228 Location New York City or vicinity. Associate, graduate technical institution, 12 years' experience of wide and general character designing and superintending construction of industrial plants, thoroughly familiar with electric street and interurban railway engineering; reporting on valuations and physical conditions.

229 Student, M. E. Cornell 1910, thorough business training with banking institution, experience in drafting and technical work and study of factory conditions. Past year employed in operating end of large steel plant. Desires to connect with manufacturing, contracting or engineering firm in position requiring progressive business ability.

230 Graduate mechanical engineer, at present employed, desires position of responsibility with compressor builders. Nine years' general experience with air compressors builders, design, testing, development of electric driven units, special problems in air and natural gas compression, sales engineering and publicity work.

231 Graduate mechanical engineering; four years' drafting-room experience in railroad motive power department and manufacturing plants, desires position leading to executive responsibility. Will consider position in engineering sales department. Good references.

CHANGES IN MEMBERSHIP

CHANGES OF ADDRESS

ALLEN, Benj. T. (1903), Ch. Engr., Harrisburg Fdy. Mch. Wks., and *for mail* 218 S. 13th St., Harrisburg, Pa.

ALMIRALL, Juan A. (1892; 1904), Htg. and Vent. Engr., Dominick and Clarke Sts., New York, and 97 McDonough St., Brooklyn, N. Y.

BENNET, Orville G., Jr. (Junior 1907), Genl. Motors Co., Detroit, Mich.

BENNETT, Geo. L. (1905), 3321 Giles Pl., Kingsbridge, New York, N. Y.

BROWN, William Clinton (1896), Ch. Engr., Humphrey Gas Pump Co., S. A. and K. Bldg., Syracuse, N. Y.

CAPEN, Thomas W. (1883), 280 Britain Ave., Benton Harbor, Mich.

CHAMBERLAIN, Harry M. (1907), Macker-Tyler Co., 31 Central St., and *for mail*, 7 Wachusett St., Worcester, Mass.

CHAPMAN, Harry Burdett (1910), Long & Chapman, Texas City, Tex.

COBLEIGH, Henry R. (Junior, 1904), Internatl. Steam Pump Co., 115 Broadway, New York, and 503 E. 8th St., Brooklyn, N. Y.

COLLINS, B. R. T. (1891; 1901), Mech. Engr. and Power Plant Economist, 19 Congress St., Boston, Mass.

COOLEY, Hugh Nelson (Associate 1910), Rep., Nordberg Mfg. Co. in Southwestern U. S. and Mex., and *for mail*, 500 Upson Ave., El Paso, Tex.

COX, Frank G. (1905; Associate, 1908), Engr., Otis Elev. Co., Dallas, Tex.

CROXTON, Herbert A. (1903), Pres. and Genl. Mgr., The Consltd. Motor Car Co., E. 72d and L. S. M. S., and the Rosamond, 6715 Euclid Ave., Cleveland, O.

DREYFUS, Theo. Frank (Junior, 1903), M. P. Inspr., Baltimore & Ohio R. R. Co., Wheeling, W. Va.

ENGLISH, Harry K. (Associate, 1908), Secy., Ottumwa Iron Wks., Ottumwa, Ia.

ERICSON, John Ernst (1909), City Engr., City of Chicago, and 4627 Kenmore Ave., Chicago, Ill.

FALLON, John (Junior, 1910), with P. R. Moses, 366 Fifth Ave., New York, N. Y.

FENNER, David C. (1906), Sales Mgr., Alden Sampson Mfg. Co., 5 W. 61st St., New York, N. Y., and *for mail*, 705 Ravine Rd., Plainfield, N. J.

GORDON, Henry Decatur (1896), 80 White St., New York, N. Y., and 15 Evergreen Pl., East Orange, N. J.

GORE, Warren W., (1908), Exper. Engr., Fairbanks Morse Mfg. Co., and *for mail*, 636 Prairie Ave., Beloit, Wis.

GREEN, Chas. Henry (Junior, 1905), Cons. Engr., 617 Peyton Bldg., Spokane, Wash.

HARDY, C. E. (Junior, 1902), Industrial Engr., Westinghouse Elec. & Mfg. Co., 165 Second St., San Francisco, Cal.

HARRINGTON, John Lyle (1903), Waddell & Harrington, Orear-Leslie Bldg., and 2927 Forest Ave., Kansas City, Mo.

HEIKEL, Daniel August (1899), Life Member; Mech. Engr., Abo, Finland.

HERSCHEL, Winslow Hobart (1910), 137 W. Swissvale Ave., Edgewood Park, Pittsburg, Pa.

HILL, Edgar Logan (Junior, 1908), Supt., Am. Steel & Wire Co., and *for mail*, P. O. Box 553, Worcester, Mass.

HOWELL, Frank B. (1901), Asst. Genl. Mgr. Sales, Am. Radiator Co., 816 S. Michigan Ave., and 1615 E. 51st St. Blvd., Chicago, Ill.

HUTCHINS, Harry C. (Junior, 1905), Designer, Pub. Service Com., Rm. 207, 51 Chambers St., and *for mail*, 15 W. 107th St., New York, N. Y.

INGALLS, Frederick D. B. (1909), Cons. Mech. Engr., 502-503 Snow Bldg., and 706½ S. Crouse Ave., Syracuse, N. Y.

JOSLYN, Paul L. (1909), Mech. Engr., Union Iron Wks., and 1953 Pine St., San Francisco, Cal.

KENT, Robert Thurston (Junior, 1905), Editor, Industrial Engineering, 90 West St., New York, N. Y., and *for mail*, 535 Church St., Bound Brook, N. J.

KESSLER, Armin Geo. (Junior, 1909), Ball Eng. Co., and *for mail*, 557 W. 9th St., Erie, Pa.

KING, George I. (1901), Ch. Engr., Middletown Car Co., Middletown, and *for mail*, 200 Brady St., Butler, Pa.

KNEIP, Walter F. (Junior, 1904), Engrg. Dept., H. H. Franklin Mfg. Co., and *for mail*, 918 Bellevue Ave., Syracuse, N. Y.

LOCKWOOD, Rutherford T. (Junior, 1904), Asst. Supt. Sone & Fleming Wks., Stand. Oil Co. of N. Y., Kinglands and Meserole Ave., and *for mail*, 144 Milton St., Brooklyn, N. Y.

McGREGOR, Alexander Grant (Junior, 1905), Douglas, Ariz.

MANLEY, Sumner M. (Junior, 1907), Asst. Mech. Engr., The Proctor & Gamble Co., Ivorydale, and *for mail*, Ivy St., Glendale, O.

MASURY, Alfred Fellows (Junior, 1904), Mech. Engr., Hewitt Motor Co., and *for mail*, 10 E. 31st St., New York, N. Y.

MILLETT, Kenneth Ballard (Junior, 1908), 215 Windham Rd., Willimantic, Conn.

MOODY, Herbert A. (1901; 1905; 1910), Cons. Industrial Engr., 178 Devonshire St., Boston, Mass.

MOODY, William O. (1907), Mech. Engr., Ill. Central R. R., and *for mail*, 864 E. 39th St., Chicago, Ill.

MOORE, Allen H. (1902), Genl. Elec. Co., Schenectady, and *for mail*, 579 Western Ave., Albany, N. Y.

MORAN, Daniel E. (1886; 1904), Cons. Engr., 55 Liberty St., New York, N. Y., and Mendham, Morris Co., N. J.

MUELLER, Victor H. (Junior, 1907), Ch. Draftsman, M. W. Kellogg Co., 117 West Side Ave., Jersey City, and *for mail*, 25 Maple Terrace, East Orange, N. J.

NAGLE, A. F. (1880), Cons. Engr., 22 S. High St., Bethlehem, Pa.

ORCUTT, Harry Fred Lee (1900), London Mgr., Birmingham Small Arms Co., Ltd., Small Heath, Birmingham, and *for mail*, Rowington Hall, nr. Warwick, England.

PARSONS, W. Everett (1899), Cons. Engr., 1639 Third Ave., New York, N. Y. and *for mail*, 240 Grafton Ave., Newark, N. J.

PATTISON, Frank A. (1903), Cons. Engr., Centurian Bldg., 1182 Broadway, New York, N. Y., and Colonia, N. J.

PENNINGTON, James H. (1902), 734 Roland Ave., Baltimore, Md.

PENNOCK, George Alger (Junior, 1903), Asst. Supt., Service and Maintenance, Western Elec. Co., Hawthorne, Ill., and *for mail*, Weston, Mass.

RANDALL, Dwight T. (1904), Resident Engr., Arthur D. Little, Inc., 70 Smith Ave., Detroit, Mich.

SAMPSON, Chas. C. (1909), Gas Engr., Ill. Steel Co., Joliet Wks., and *for mail*, 506 Western Ave., Joliet, Ill.

SEAMAN, Edwin H. (Junior, 1908), Ins. Engr. with Underwriters at Am. Lloyds, 123 William St., New York, and *for mail*, Lock Box 6, Wantagh, Nassau Co., N. Y.

SHELDON, Samuel B. (Junior, 1900), 117 Church St., Bethlehem, Pa.

SNYDER, William E. (1900), Mech. Engr., Am. Steel & Wire Co., Frick Bldg., and *for mail*, 1712 Morrell St., N. S.,Pittsburg, Pa.

STRINGHAM, Joseph S. (1903), Pres., Frontier Engrg. Co., 1309 Majestic Bldg., and 275 Seminole Ave., Detroit, Mich.

SUMNER, Harry W. (Junior, 1900), Pres., Rainier Fdy. Co., Stacy and E. Waterway Sts., and 1643 Federal Ave., N., Seattle, Wash.

TIMMIS, Walter S. (1906), Cons. Engr., Marbridge Bldg., 47 W. 34th St., New York, and Avondale St., Brooklyn Manor, Woodhaven. L. I., N. Y.

SWEET, Charles E. (1907), 135 Taylor Ave., Detroit, Mich.

TOLTZ, Max (1904), Cons. Engr., 1614 Pioneer Press Bldg., and 433 Holly Ave., St. Paul, Minn.

TOWNSEND, Harry P. (Junior, 1904), Secy. and Genl. Mgr., The H. P. Townsend Mfg. Co., 10 Hoadley Pl., Hartford, Conn.

VALENTINE, Louis Rossiter, (Junior, 1907), Dodge, Day & Zimmerman, 608 Chestnut St., and *for mail*, 1433 N. 16th St., Philadelphia, Pa.

VAN VALKENBURGH, Ralph D. (1901; Associate, 1905), Dist. Mgr., Colonial Steel Co., 213 W. Lake St., and *for mail*, Hotel Ontario, 620 N. State St., Chicago, Ill.

VON GOEBEN, Carl (1899), Wks. Mgr., The Payne & Joubert Mch. & Fdy. Co., and *for mail*, P. O. Box 930, Birmingham, Ala.

WELLS, J. Barnard (Junior, 1909), Clerk, care Supt., S. P. L. A. & S. L. R. R., and *for mail*, 421 W. Adams St., Los Angeles, Cal.

WERST, Chas. Wm. (1909), Asst. Supt., Lima Loco. & Mch. Co., and *for mail* 1534 Lakewood Ave., Lima, O.

WILLARD, Lewis Leigh (1907; 1910), Ch. Mech. Engr., Allis-Chalmers Co., and *for mail*, care W. J. Rainey, Uniontown, Pa.

WILLIAMSON, Alfred (Junior, 1902), Mech. Engr., Dept. Water Supply, Gas & Elec. 13 Park Row, New York, and *for mail*, P. O. Box 386, Bronxville, N. Y.

WILLSON, Ernest M. (Associate, 1909), Ch. Draftsman, Hart-Parr Co., and *for mail*, 610 Illinois St., Charles City, Ia.

YARYAN, Homer T. (1892), V. P., The Yaryan Naval Stores Co., Toledo, O.

NEW MEMBERS

McKINNON, William R. (Junior, 1910), 5031 National Ave., West Allis, Wis.

DEATHS

CALDWELL, John A., April 7, 1911.
YARYAN, Edward B., April 28, 1911.

COMING MEETINGS

JUNE—JULY

Advance notices of annual and semi-annual meetings of engineering societies are regularly published under this heading and secretaries or members of societies whose meetings are of interest to engineers are invited to send such notices for publication. They should be in the editor's hands by the 15th of the month preceding the meeting. When the titles of papers read at monthly meetings are furnished they will also be published

AMERICAN CHEMICAL SOCIETY

June 28–July 1, annual convention, Indianapolis, Ind. Secy., Chas. L. Parsons, Durham, N. H.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

June 21–24, annual meeting, Chicago, Ill. Reports by committees on Chemical Engineering Education and Standardization of Boiler Tests. Secy., J. C. Olsen, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

June 26–30, annual convention, Chicago, Ill. Secy., R. W. Pope, 29 W. 39th St., New York.

AMERICAN INSTITUTE OF MINING ENGINEERS

June 6, Glen Summit meeting, Glen Summit Springs Hotel, Glen Summit Springs, Pa. Secy., Joseph Struthers, 29 W. 39th St., New York.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION

June 14–16, Spring Convention, Marlborough-Blenheim, Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

AMERICAN SOCIETY FOR TESTING MATERIALS

June 27–30, annual meeting, Atlantic City, N. J. Secy., Edgar Marburg, Univ. of Penn., Philadelphia, Pa.

AMERICAN SOCIETY OF CIVIL ENGINEERS

June 13–16, annual meeting, Chattanooga, Tenn. Secy., C. W. Hunt, 220 W. 57th St., New York.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

May 30–June 2, Spring Meeting, Pittsburg, Pa. Monthly meetings: June 3, Philadelphia, Pa.; June 7, St. Louis, Mo.; June 28, San Francisco, Cal. Secy., Calvin W. Rice, 29 W. 39th St., New York.

AMERICAN WATER WORKS ASSOCIATION

June 6–10, annual convention, Rochester, N. Y. Secy., J. M. Diven, 14 George St., Charlestown, S. C.

ASSOCIATION OF RAILWAY ELECTRICAL ENGINEERS

June 16–17, semi-annual convention, Washington, D. C. Secy., J. A. Andreucetti, C. & N. W. Ry., Chicago, Ill.

ASSOCIATION OF RAILWAY TELEGRAPH SUPERINTENDENTS

June 19–23, annual convention, Boston, Mass. Secy., P. W. Drew, Wisconsin Central Railway, Chicago, Ill.

ASSOCIATION OF TRANSPORTATION AND CAR ACCOUNTING OFFICERS

June 20–21, annual meeting, Cape May, N. J. Secy., G. P. Conrad, 24 Park Pl., New York.

CANADIAN GAS ASSOCIATION

June 22–24, annual meeting, Quebec City, Quebec. Secy., John Keillor, Hamilton, Ont.

INTERNATIONAL RAILWAY GENERAL FOREMEN'S ASSOCIATION

July 25–27, annual meeting, Chicago, Ill. Secy., L. H. Bryan, D. & I. R. Ry., Two Harbors, Minn.

MASTER CAR BUILDERS' ASSOCIATION

June 19–21, Spring Convention, Marlborough-Blenheim, Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

NATIONAL ELECTRIC LIGHT ASSOCIATION

May 29–June 2, annual convention, New York. Secy., T. C. Martin, 29 W. 39th St.

NATIONAL GAS AND GASOLINE ENGINE TRADES ASSOCIATION

June 20-23, Spring Convention, Detroit, Mich. Secy., Albert Stritmatter, Cincinnati, O.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

June 27–29, annual convention, Pittsburg, Pa. Secy., H. H. Norris, Cornell University, Ithaca, N. Y.

SOCIETY OF AUTOMOBILE ENGINEERS

June 15–17, midsummer meeting, Dayton, O. Genl. Mgr., Coker F. Clarkson, 1451 Broadway, New York.

MEETINGS IN THE ENGINEERING SOCIETIES BUILDING

Date	Society	Secretary	Time
June			
1	Blue Room Engineering Society	W. D. Sprague	8.00 p.m.
8	Illuminating Engineering Society	P. S. Millar	8.00 p.m.
8	Institute of Operating Engineers	M. W. Rice	8.00 p.m.
20	New York Telephone Society	T. H. Lawrence	8.15 p.m.
26	National Isolated Power Plant Association	E. D. Fieux	8.00 p.m.

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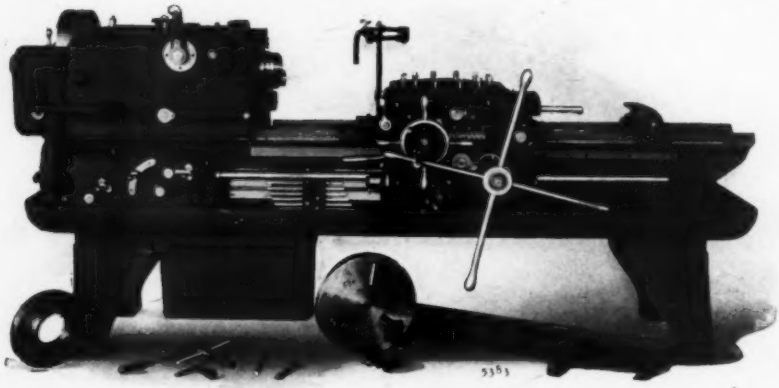

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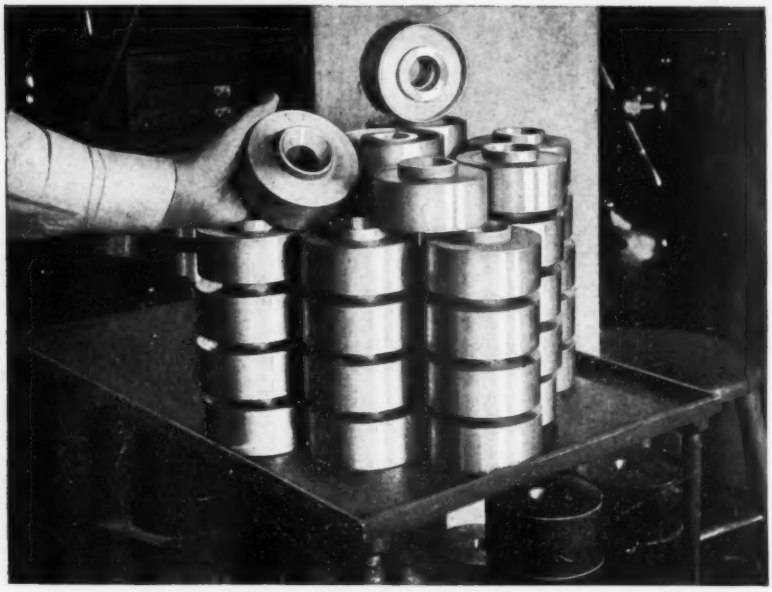

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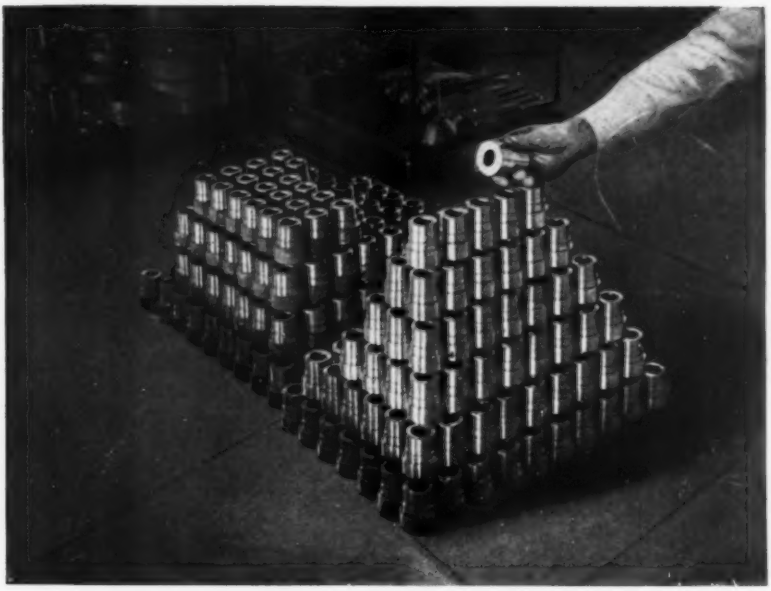

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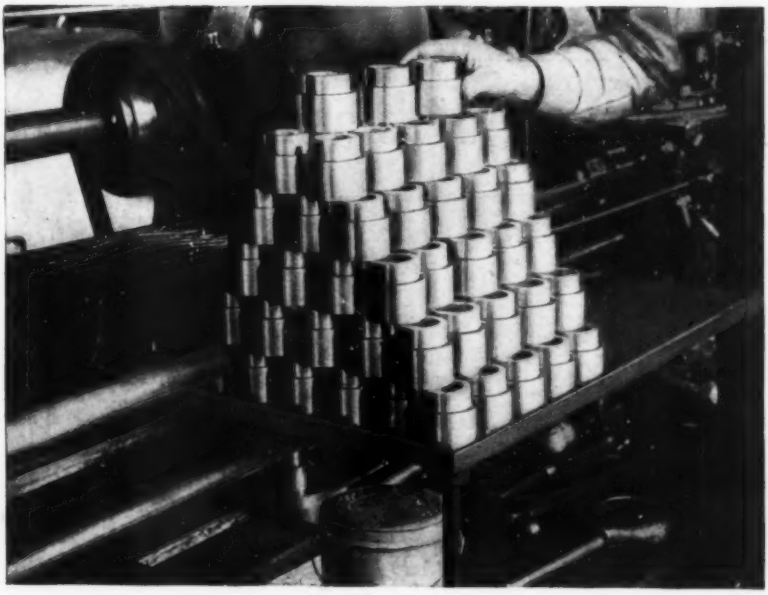

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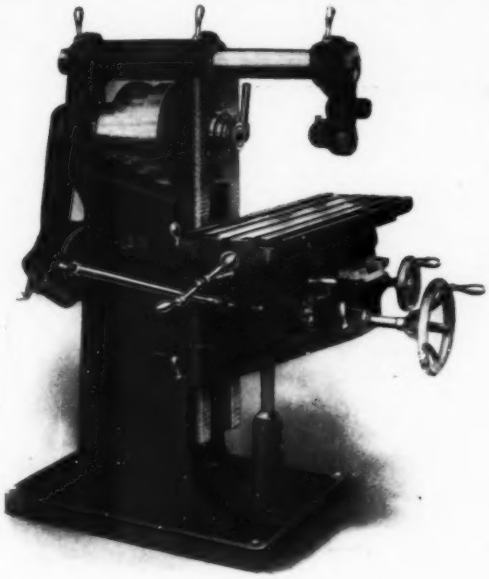

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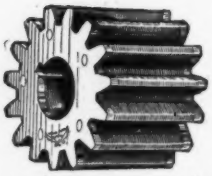

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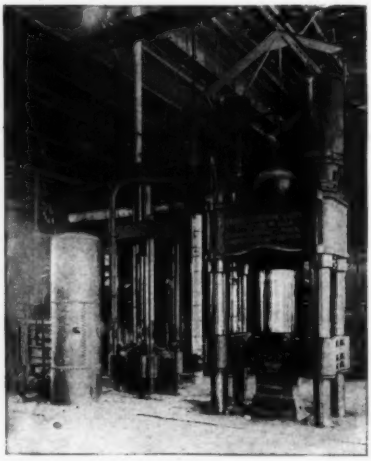

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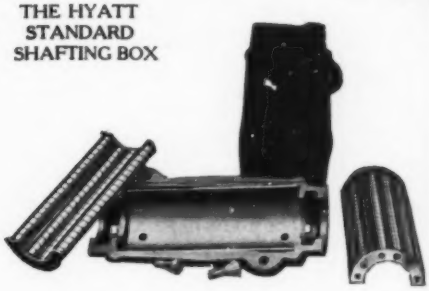

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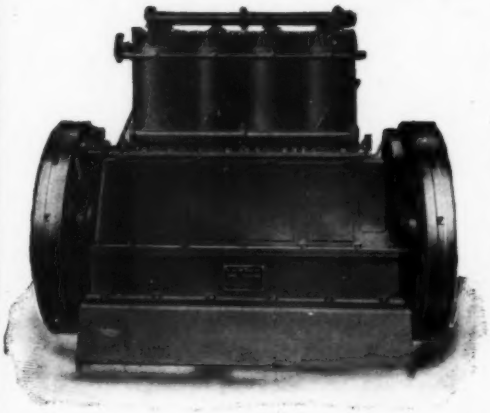

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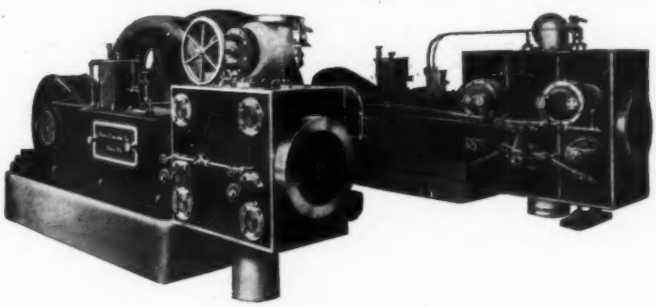

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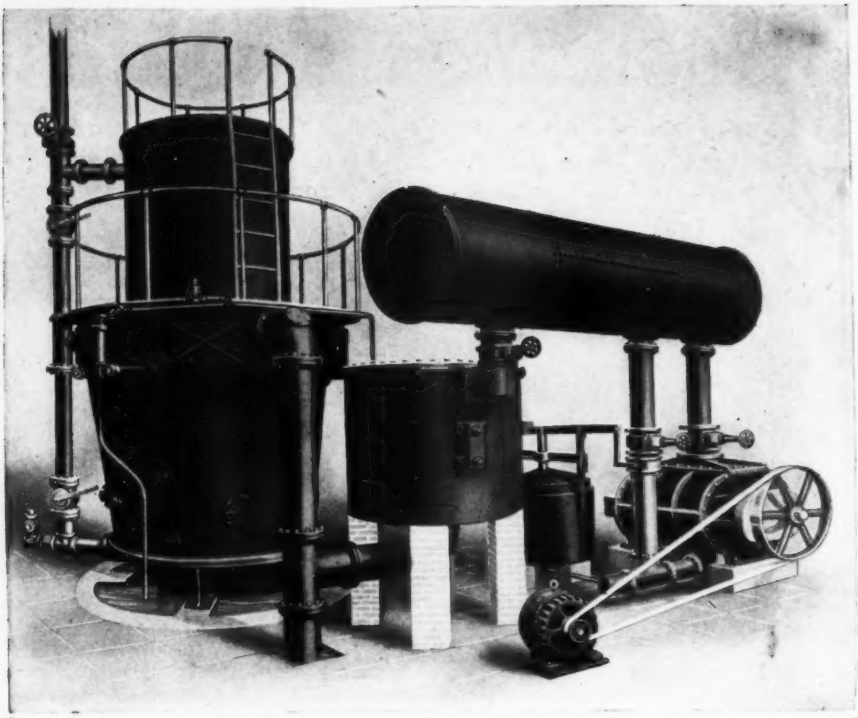

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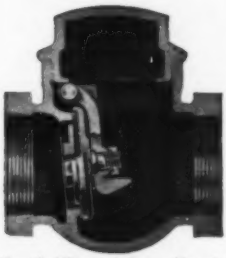
Outside View of Standard Valve for 125 pounds working pressure.



Inside View, showing Leather Disc for Hydraulic Service.

Nelson Bronze Swing Checks

Simple.
None like it.
No *Joints.*
No *Plugs.*
Body cast in *one piece.*
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Only *five parts* in steam valve, with bronze disc; (the leather disc and nut are added for hydraulic work).

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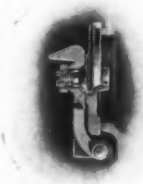

Showing the Bronze Disc Mechanism.

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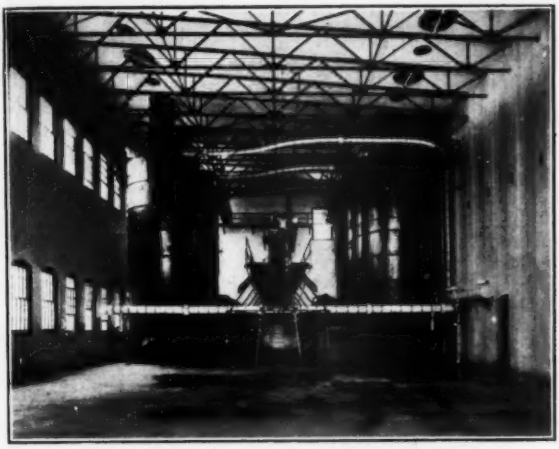

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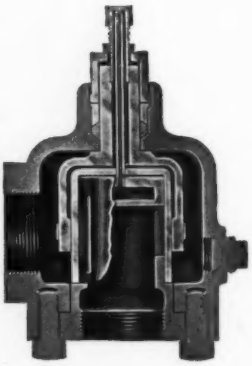

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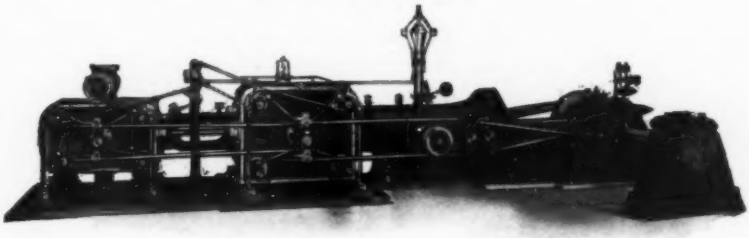

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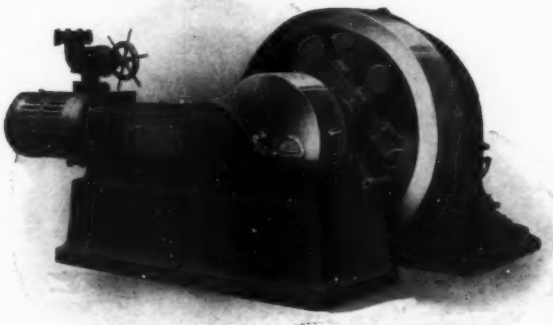

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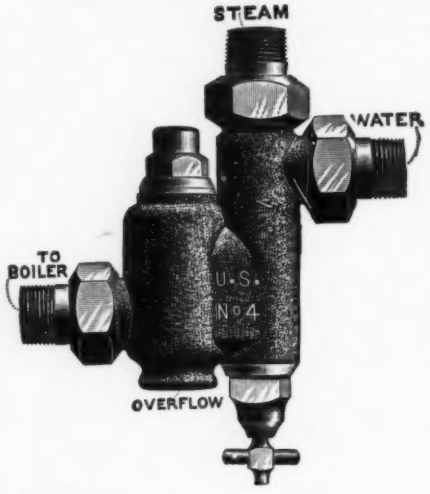

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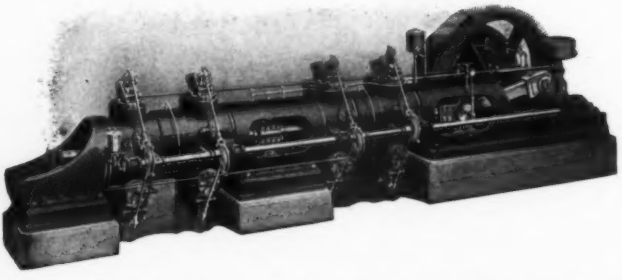

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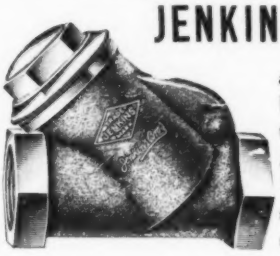

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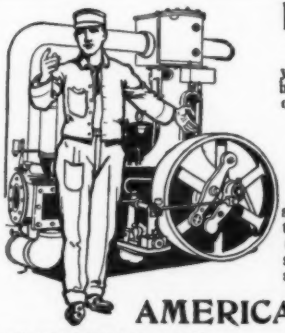

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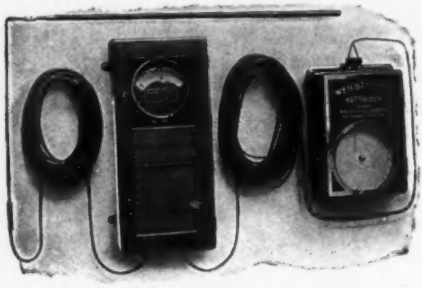

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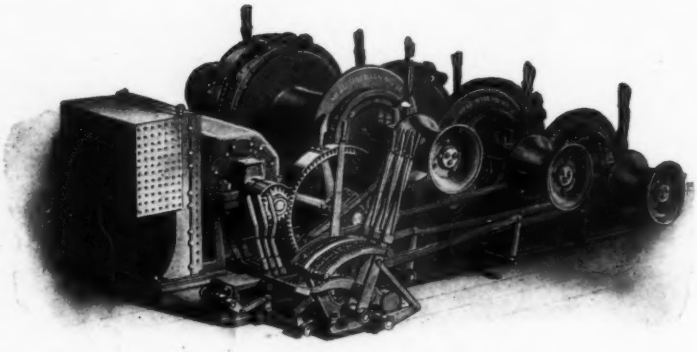

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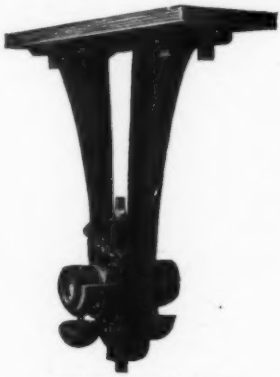

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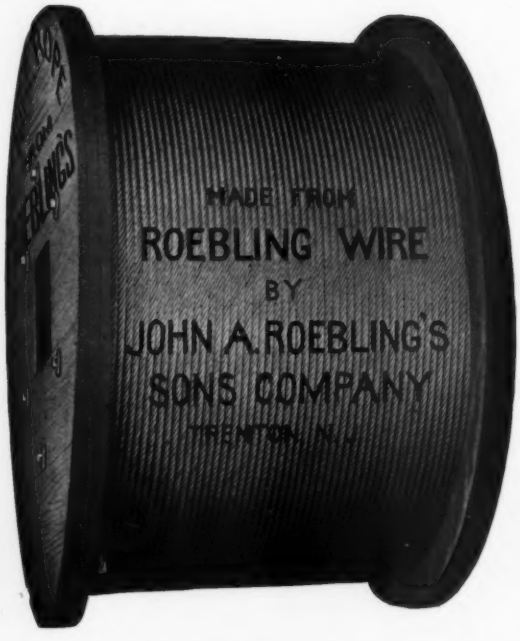

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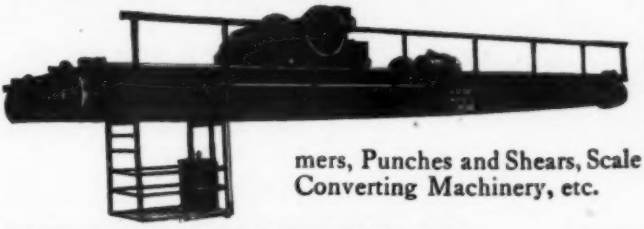

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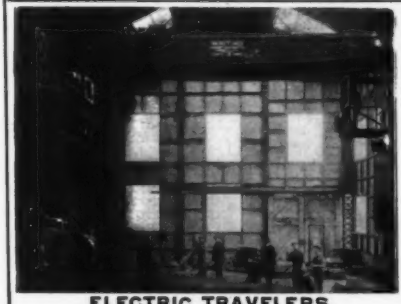

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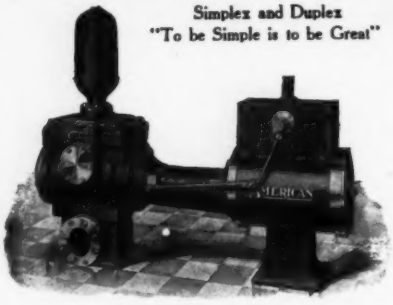

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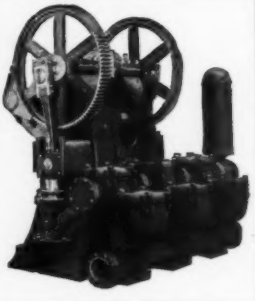

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2. In Building Additions

If it has been found necessary to build additions, it is important to lay them out in such a way as to secure the most economical routing of materials and to comply in other particulars with the requirements of scientific management. These additions must lend themselves readily to still further expansion.

3. In Laying Out New Plants

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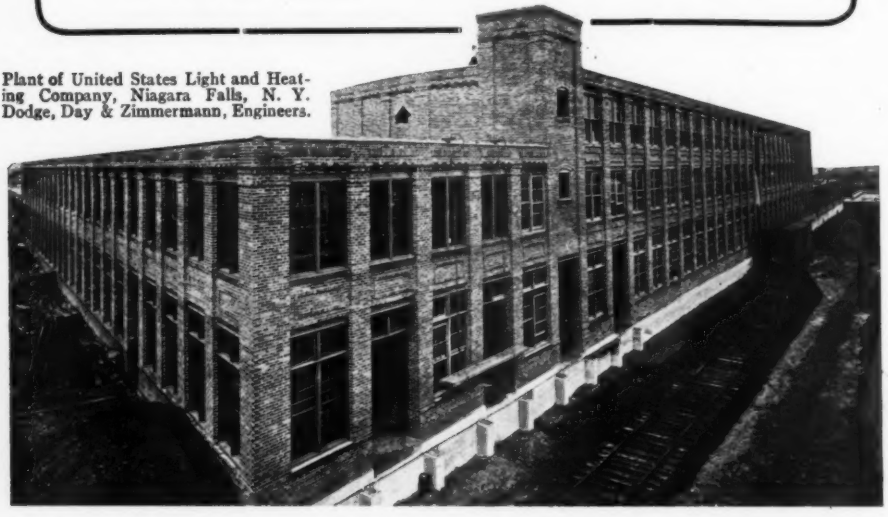

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